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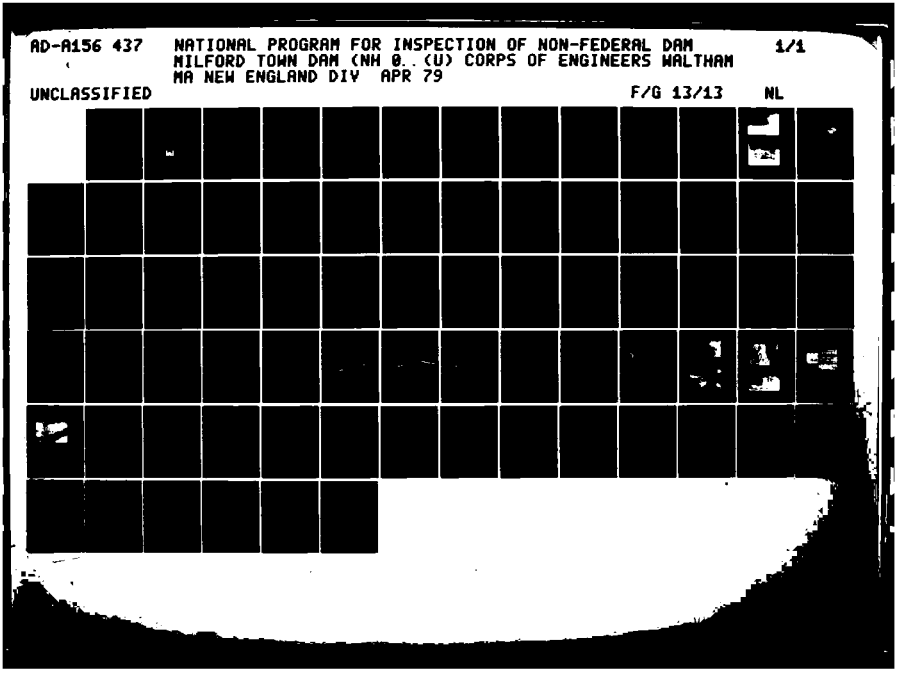

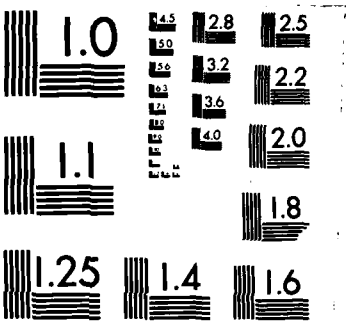

(7)

MERRIMACK RIVER BASIN
MILFORD, NEW HAMPSHIRE

MILFORD TOWN DAM
NH 00312
NHWRB 159.02

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS. 02154

APRIL 1979

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19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

DAMS, INSPECTION, DAM SAFETY,

Merrimack River Basin
Milford, New Hampshire
Souhegan River

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

THe dam is a 195 ft. long Concrete gravity dam with a 173 ft. long spillway. It is small in size with a low hazard potential. The test flood is between the 50 yr. and 100 yr. flood. The dam is in fair condition. A program for annual technical inspections should be instituted.

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DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02154

REPLY TO
ATTENTION OF:
NEDED

JUN 0 3 1979

Honorable Hugh J. Gallen
Governor of the State of New Hampshire
State House
Concord, New Hampshire 03301

Dear Governor Gallen:

I am forwarding to you a copy of the Milford Town Dam Phase I Inspection Report, which was prepared under the National Program for Inspection of Non-Federal Dams. This report is presented for your use and is based upon a visual inspection, a review of the past performance and a brief hydrological study of the dam. A brief assessment is included at the beginning of the report. I have approved the report and support the findings and recommendations described in Section 7 and ask that you keep me informed of the actions taken to implement them. This follow-up action is a vitally important part of this program.

A copy of this report has been forwarded to the Water Resources Board, the cooperating agency for the State of New Hampshire. In addition, a copy of the report has also been furnished the owner, Town of Milford, Milford, New Hampshire 03055.

Copies of this report will be made available to the public, upon request, by this office under the Freedom of Information Act. In the case of this report the release date will be thirty days from the date of this letter.

I wish to take this opportunity to thank you and the Water Resources Board for your cooperation in carrying out this program.

Sincerely yours,

MAX B. SCHEIDER
Colonel, Corps of Engineers
Division Engineer

Incl
As stated

NATIONAL DAM INSPECTION PROGRAM

PHASE I INSPECTION REPORT

Identification No.:	NH 00312
NHWRB No.:	159.03
Name of Dam:	MILFORD TOWN DAM
Town:	Milford
County and State:	Hillsborough, New Hampshire
River:	Souhegan River
Date of Inspection:	November 1, 1978

BRIEF ASSESSMENT

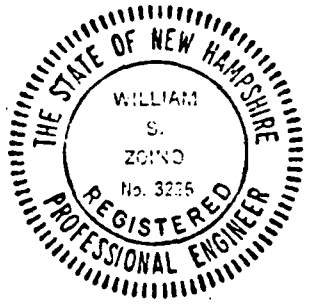
Milford Town Dam is a 195 foot long concrete gravity dam with a 173 foot long spillway. A stop log controlled sluice gate structure is located at the left end of the dam, and an abandoned intake structure to an old mill building is located at the right end of the dam. The dam, which has a maximum height of 12 feet, is owned by the town of Milford. The dam, which was originally constructed in 1935 to provide power to the mill building on the right bank, was completely reconstructed in 1966 to bring it to its present configuration.

The dam lies on the Souhegan River just downstream from the Route 13 bridge in the town of Milford. The dam presently improves the aesthetics of the Souhegan River at this point. The drainage area consists of 138 square miles of moderately to steeply sloping forested terrain. Developed areas are only a small portion of the overall drainage area. The dam's maximum impoundment of 130 acre-feet and maximum height of 12 feet place the dam in the SMALL size category while the small chances for property damage or loss of life in the event of a dam failure result in a hazard potential classification of LOW.

Based on the size and hazard potential classifications and in accordance with the Corps' of Engineers guidelines, the Test Flood (TF) is between the 50 year flood and the 100 year flood. Since the hazard potential classification is on the low side of the LOW category, the 50 year flood was chosen as the TF resulting in a flow of 8850 cfs. Under this flow the peak flow elevation would overtop the sluice gate structure at the left end of the dam by one foot.

The dam is in FAIR condition at the present time. It is recommended that a qualified registered engineer be retained to determine if the right intake structure is adequately sealed. Recommended remedial measures include repair of the deteriorated concrete on the right upstream and downstream training walls, repair of the concrete on the right intake structure, and removal of vegetation growing between the two right downstream training walls. The amount and turbidity of the seepage observed at the right end of the dam should be monitored by visual observation for any changes that might require remedial action. A program of annual technical inspections should be instituted.

The recommendations and improvements outlined above should be implemented within one year of receipt of this report by the owner.



William S. Zoino
N.H. Registration 3226

Nicholas A. Campagna, Jr.
California Registration 21006

This Phase I Inspection Report on **Milford Town Dam** has been reviewed by the undersigned Review Board members. In our opinion, the reported findings, conclusions, and recommendations are consistent with the Recommended Guidelines for Safety Inspection of Dams, and with good engineering judgment and practice, and is hereby submitted for approval.

Joseph A. McElroy

JOSEPH A. MCELROY, MEMBER
Foundation & Materials Branch
Engineering Division

Carney M. Terzian

CARNEY M. TERZIAN, MEMBER
Design Branch
Engineering Division

Joseph W. Finegan, Jr.

JOSEPH W. FINEGAN, JR., CHAIRMAN
Chief, Reservoir Control Center
Water Control Branch
Engineering Division

APPROVAL RECOMMENDED:

Joe B. Fryar

JOE B. FRYAR
Chief, Engineering Division

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Test Flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the Test Flood should not be interpreted as necessarily posing a highly inadequate condition. The Test Flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

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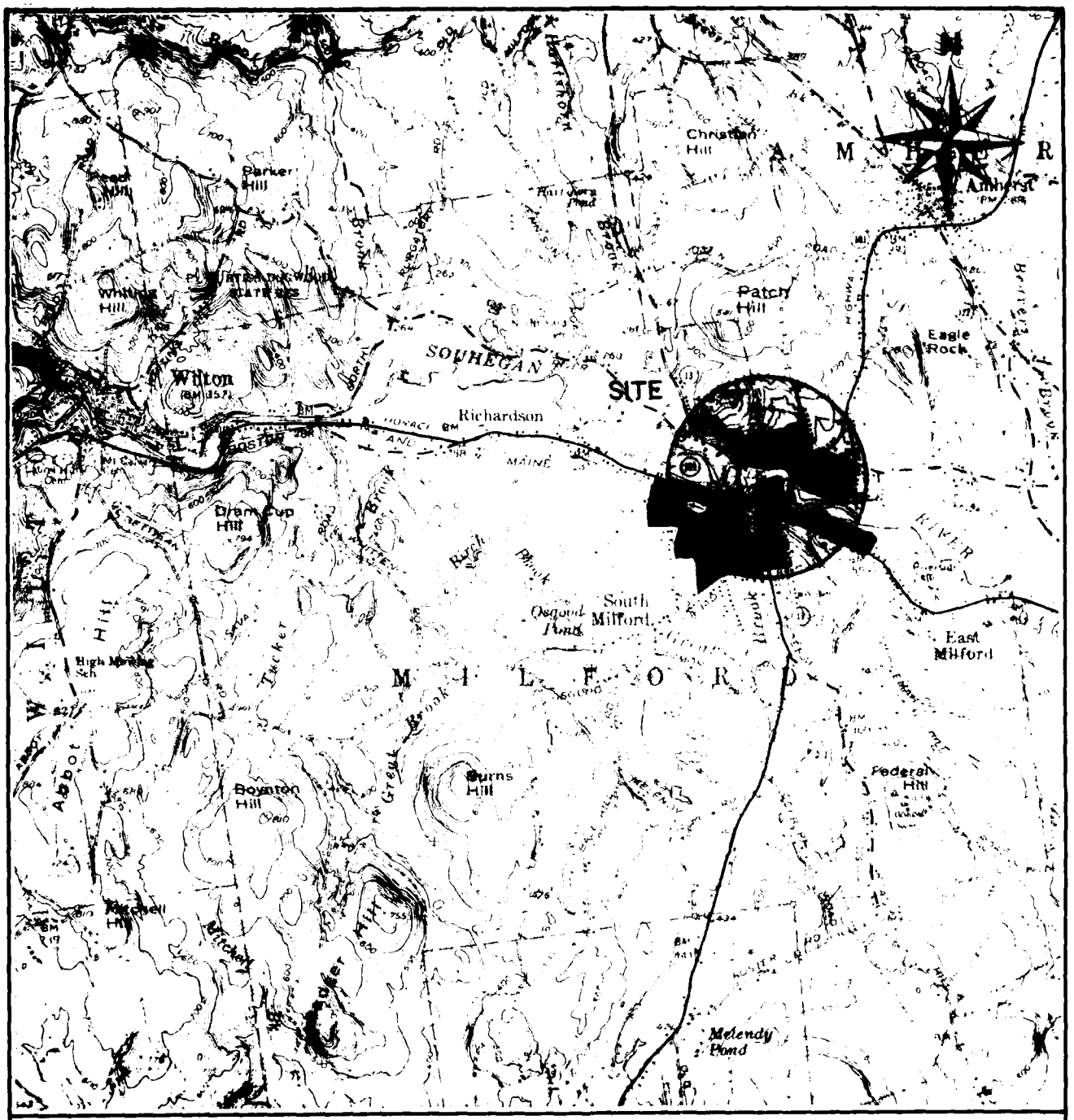
Overview of dam from right side of downstream channel



— SCALE —

0 1/2 1 2 MILES

FROM: USGS MILFORD, N.H. QUADRANGLE MAP

GOLDBERG, ZOINO, DUNNICLIFF & ASSOC., INC.
GEOTECHNICAL CONSULTANTS
NEWTON UPPER FALLS, MASS.

U.S. ARMY ENGINEER DIV. NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

LOCUS PLAN

FILE No. 2201

MILFORD TOWN DAM — NEW HAMPSHIRE

SCALE AS NOTED

DATE JANUARY 1979

PHASE I INSPECTION REPORT

MILFORD TOWN DAM

SECTION 1

PROJECT INFORMATION

1.1 General

(a) Authority

Public Law 92-367, August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a national program of dam inspection throughout the United States. The New England Division of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the New England Region. Goldberg, Zoino, Dunnicliff & Associates, Inc. (GZD) has been retained by the New England Division to inspect and report on selected dams in the State of New Hampshire. Authorization and notice to proceed was issued to GZD under a letter of November 28, 1978 from Colonel Max B. Scheider, Corps of Engineers. Contract No. DACW 33-79-C-0013 has been assigned by the Corps of Engineers for this work.

(b) Purpose

(1) Perform technical inspection and evaluation of non-federal dams to identify conditions which threaten the public safety and thus permit correction in a timely manner by non-federal interests.

(2) Encourage and prepare the states to initiate quickly effective dam safety programs for non-federal dams.

(3) Update, verify, and complete the National Inventory of Dams.

(c) Scope

The program provides for the inspection of non-federal dams in the high hazard potential category based upon location of the dams and those dams in the significant hazard potential category believed to represent an immediate danger based on condition of the dam.

1.2 Description of Project

(a) Location

Milford Town Dam lies on the Souhegan River in Milford, New Hampshire. The dam is located approximately 200 feet downstream from the bridge carrying New Hampshire Route 13 over the Souhegan River in Milford, New Hampshire. The portion of the USGS Milford, N.H. quadrangle presented previously shows this locus. Figure 1 of Appendix B is a site plan prepared from the map and the site visit.

(b) Description of Dam and Appurtenances

The dam is a 195 foot long concrete gravity structure founded on bedrock. The dam has a maximum height of 12 feet and has one operable control structure. The control structure is a sluice gate with a stop log weir located at the left end of the dam. An abandoned intake structure is located on the right end of the dam. The spillway is a 173 foot long concrete gravity structure founded on bedrock.

Upstream and downstream training walls are located on the right side of the dam. The upstream wall is a cemented squared stone wall. A similar wall is located on the left upstream bank. Both walls extend to the Route 13 bridge located upstream from the dam. A dry and cemented stone masonry wall is located on the right downstream side. This wall serves as the foundation for the building on the right side. A concrete capped dry rubble stone masonry wall jutting out into the stream at a 30 degree angle is located at the end of the building. The building was formerly a mill building which is now being converted to other uses.

(c) Size Classification

The dam's maximum impoundment of 130 acre-feet and maximum height of 12 feet place the dam in the SMALL size category as defined in the "Recommended Guidelines."

(d) Hazard Potential Classification

The town of Milford lies below the dam but because of the small size of the dam and the flow characteristics

of the downstream channel, no damaging flooding is expected in the event of a dam failure. For this reason a LOW hazard potential classification is warranted.

(e) Ownership

The original dam was built in 1935 to provide power for the mill building on the right bank. The Public Service Company of New Hampshire owned the dam in 1940 according to records of the New Hampshire Water Resources Board (NHWRB). At some time before 1966 the town of Milford acquired the old dam and in 1966 reconstructed the dam to its present configuration. The construction was performed through the auspices of the Town Conservation Commission. At present the town of Milford owns the dam.

(f) Operator

The dam is operated through the town Department of Public Works. Mr. Robert Courage is the superintendent of public works and can be reached by telephone at 603-673-1662.

(g) Purpose of Dam

The original dam was built to provide power for the mill building. At present the dam improves the aesthetics of the Souhegan River at this point.

(h) Design and Construction History

The original dam was a combination concrete gravity and wood dam with a total height of approximately 20 feet. Through many years with no maintenance the dam fell into a state of disrepair. In 1966 the town of Milford constructed the present dam which has a maximum spillway height of approximately 7 feet. The former intake openings to the mill had been sealed previously and the sluiceway on the left side was added in 1966.

(i) Normal Operational Procedures

At the present time no operational procedure is in effect at the dam.

1.3 Pertinent Data

(a) Drainage Area

The total drainage area for the dam is 138 square miles. Most of this area is moderately to steeply sloping forested terrain. Only a small fraction of the entire drainage area is developed.

(b) Discharge at Damsite

(1) The only operable outlet at the dam is the sluiceway on the left side of the dam. At the present time stop logs are in place to approximately the spillway crest elevation and are apparently not removed at any time. The invert elevation of the sluiceway is elevation 230.8.

(2) No records of flow or stage are known to be available for Milford Town Dam. The nearest gage on the Souhegan is the USGS gage No. 01094000 at Merrimack, N.H. This gage is downstream of Milford Town Dam and has a drainage area of 171 square miles. The peak discharge at the gage in 78 years of record is 16,900 cfs on March 19, 1936. The peak at Milford Town Dam is estimated to be 14,400 cfs based on drainage area relationships.

(3) The ungated spillway capacity with water level at the top of the dam, elevation 240.4 is 6870 cfs.

(4) Ungated spillway capacity at test flood elevation - Dam overtopped by test flood

(5) Gated spillway capacity at recreational pool - NA

(6) Gated spillway capacity at test flood level - NA

(7) Total spillway capacity at test flood elevation - See (4) above

(8) Total project discharge at test flood - see (4) above

(c) Elevation (ft. above MSL)

(1) Streambed at centerline of dam: 228.3

(2) Maximum tailwater: Unknown

(3) Upstream portal invert diversion tunnel: NA

(4) Recreation pool: NA

(5) Full flood control pool: NA

(6) Spillway crest: 235.2

(7) Design surcharge (original design): Unknown

(8) Top dam: 240.4

(9) Test flood design surcharge: 241.4

(d) Reservoir

(1) Length of maximum pool: 3400 ft. ±

(2) Length of normal pool: 1700 ft. ±

(3) Length of flood control pool: NA

(e) Storage (acre-feet)

(1) Normal pool: 40 ±

(2) Flood control pool: NA

(3) Spillway crest pool: 40 ±

(4) Top of dam: 140 ±

(5) Test flood pool: 165 ±

(f) Reservoir Surface (acres)

(1) Normal pool: 8 ±

(2) Flood-control pool: NA

(3) Spillway crest: 8 ±

(4) Test flood pool: 20 ±

(5) Top dam: 18 ±

(g) Dam

(1) Type: Concrete gravity

(2) Length: 195 ft.

(3) Height: 12 ft.

(4) Top width: 1.5 ft.

(5) Side slopes: NA

(6) Zoning: NA

(7) Impervious core: NA

(8) Cutoff: None

(9) Grout curtain: Unknown

(10) Other: NA

(h) Diversion and Regulating Tunnel: NA

(i) Spillway

(1) Type: Concrete gravity

(2) Length of weir: 173 ft.

(3) Crest elevation: 235.2

(4) Gates: None

(5) U/S channel: Width of river

(6) D/S channel: Width of river

(7) General: NA

(j) Regulating Outlets

The sluiceway at the left side of the dam is the only operable regulating outlet. The sluiceway is 3.5 feet wide with invert elevation 230.8. Stop logs are in place to elevation 235.2. There is no control mechanism for removing stop logs.

SECTION 2 - ENGINEERING DATA

2.1 Design Records

The design of the dam is quite simple and incorporates no unusual features. Several design drawings are available for the reconstructed dam (1966). These drawings show plans and cross sections of the dam and spillway. The pertinent drawings are included in Appendix B.

2.2 Construction Records

No as-built construction drawings are available for the dam.

2.3 Operational Records

There are no operational records for the dam.

2.4 Evaluation of Data

(a) Availability

Because of the availability of the design drawings, an overall satisfactory assessment for availability is warranted.

(b) Adequacy

The lack of in-depth engineering data does not permit a definitive review. Therefore, the adequacy of the dam cannot be assessed from the standpoint of reviewing design and construction data. This assessment is thus based primarily on the visual inspection, past performance, and sound engineering judgment.

(c) Validity

Since the observations of the inspection tear generally confirm the information contained in the design drawings, a satisfactory evaluation for validity is indicated.

SECTION 3 - VISUAL OBSERVATIONS

3.1 Findings

(a) General

Milford Town Dam is in FAIR condition at the present time. The gated intake structure is in poor condition.

(b) Dam

(1) Left Abutment Structure and End Wall

This structure (Photos 4 and 6 and Figure B-4) is a reinforced concrete faced and capped dry stone masonry structure. A sluiceway with a stop log weir is located in the structure. The sluiceway is located next to the left bank, and the spillway is connected to the right end of the abutment structure. The spillway axis is splayed at a 60 degree angle upstream of the structure. A concrete training wall extends approximately 12 feet upstream and a buttress pier 3 feet 9 inches long and 18 inches wide also extends upstream from the structure.

Stop log slots 4 inches wide are cast into the training wall and buttress pier. The clear opening between the training wall and buttress pier is 3.5 feet. At the time of inspection 3 inch thick stop logs were in place to the spillway crest elevation. The outlet tunnel has a sloping concrete sill 4 inches thick with dry squared stone masonry side walls and headers. The tunnel invert elevation is 4.4 feet below the spillway crest.

The concrete facing, cap, and sill are in good condition with no evidence of spalls, cracks, or efflorescence. The exposed dry stone masonry is in good condition with no evidence of displaced stones, bulging, or other signs of distress. The stop logs and guides are in good condition.

(2) Spillway

The spillway (overview photo) is a concrete gravity structure with a total length of 173 feet. The spillway is "V" shaped with an apex angle of

approximately 20 degrees. The apex is approximately 85 feet from the left abutment structure. Approximately 10 feet from the structure housing the old dual sluice gates the spillway axis rotates approximately 45 degrees downstream and abuts the building wall at a 90 degree angle. The downstream face is constructed at a 1.5 horizontal to 1 vertical slope while the upstream face is vertical.

Some minor erosion at the base of the structure was observed. This is attributed to difficult construction forming. In general, however, the structure is in good condition with no evidence of spalls, cracks, or efflorescence.

(3) Right Intake Structure

The structure houses two timber sluice gates 9 feet wide, 8.5 feet high, and six inches thick (Photo 2). The downstream wall of the structure connects to the spillway. The other end of the structure is adjacent to the old mill building on the right bank. The sluice gates were formerly used as intakes for power generation in the building.

At present both sluice gates are rotted and inoperable. The operating mechanism of the gate on the downstream side consists of 2 hand wheels. The other gate was operated by a steel rod placed in a sprocket which actuated a spindle gear. Upstream of the sluice gates are timber stop logs six inches thick set in "Z" shaped guides at an approximate batter of 4 horizontal to 12 vertical. The tops of the stop logs are approximately 3 feet above the crest elevation. The stop logs are in good condition.

Vertical steel trash racks are set between the gates and the stop logs. These trash racks are rusted, and one panel is missing from the upstream intake. Penstocks connect the sluice gates to the former power generation equipment. The method used to seal the penstocks could not be observed. The outlet from the building is located approximately 150 feet downstream of the spillway.

The intermediate pier above the stop log guides and the downstream wall of the structure is spalled over 10 percent of its surface area.

The roof has spalled over 50 percent of its surface area. This spalling is attributed to moisture intrusion which has been subjected to alternating freeze and thaw cycles. The downstream wall has a continuous horizontal crack approximately 3 feet above crest level which is effloresced. The exposed concrete of this structure is eroded for a vertical distance of 2 feet above crest level. The erosion is attributed to ice damage.

(4) Upstream Training Walls

The stone masonry wall adjacent to the intake structure (Photo 2) is founded on a 10 foot long concrete foundation. The concrete is eroded over the entire interface with the cemented stone masonry wall. This erosion is up to 12 inches deep. Approximately 10 feet of the adjacent upstream wall has been undermined and settled. Stepped cracks up to 3 inches high are visible. Random fill has been placed in front of the wall. The remainder of the wall does not show any evidence of displaced stones, bulges, or other signs of distress. The mortared joints are effloresced.

The left upstream wall with the exception of minor joint efflorescence, is in good condition with no evidence of displaced stones, bulges, or other signs of distress.

(5) Downstream Training Walls

The concrete (Photo 2) located between the right intake structure and the cemented stone masonry wall has a series of horizontal cracks and is effloresced. The cracks are located about 5 feet above the spillway crest. The downstream continuation of the wall is approximately 15 feet high and serves as the building foundation wall. The wall is in good condition with no evidence of displaced stones, bulges, or other signs of distress. The mortared joints are effloresced.

A low stone masonry wall in front of the aforementioned wall has begun to unravel.

Trees up to four inches in diameter are growing at the interface of these walls.

The downstream end of the building (Photo 5) consists of a two span concrete rigid frame. The openings served as an outlet for the power generating facilities. The training wall, which was located immediately upstream of the outlets, has been completely demolished.

The left downstream dry stone masonry training wall is in fair condition with no evidence of displaced stones, bulges, or other signs of distress.

3.2 Evaluation

Milford Town Dam is in FAIR condition. The spillway and left abutment structure are in good condition although some minor erosion at the downstream base of the spillway was noted. The right intake structure is in poor condition, and the various upstream and downstream training walls are in varying degrees of condition as discussed in Section 3.1 (b) 4 and 5 above.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 Procedures

No operational procedures are performed at the dam. The stop logs in the sluiceway are left in place at approximately the spillway crest elevation. There are no hooks on the stoplogs to remove them.

4.2 Maintenance of Dam

No maintenance of the dam is presently performed.

4.3 Maintenance of Operating Facilities

The only operable structure is the stop log structure. Although the structure is not maintained, the structure is operable.

4.4 Description of Any Warning System in Effect

No warning system is in effect for this dam.

4.5 Evaluation

The operating and maintenance procedures for the dam need to be more explicitly defined as to whom has the responsibility for operation and maintenance. In general, no operation of the dam is necessary because of the low head and long spillway of the dam. Apparently, no one has accepted the responsibility for maintaining and operating the dam although available data indicates that Mr. Robert Courage of the Department of Public Works is responsible for the dam and its operation.

SECTION 5 - HYDRAULICS/HYDROLOGY

5.1 Evaluation of Features

(a) General

Milford Town Dam is a concrete, gravel, run-of-the-river structure on the Souhegan River in Milford, New Hampshire. The reservoir it forms is basically for aesthetic purposes.

The Souhegan River at the dam has a drainage area of 138 square miles. Runoff from a portion of this area is affected by numerous ponds and reservoirs including 13 Soil Conservation Services flood control dams.

(b) Design Data

Data sources available for Milford Town Dam include prior inventory and inspection reports, plans for the dam's 1966 reconstruction, and a 1977 Flood Insurance Study (FIS). The prior inventory reports available are the New Hampshire Water Control Commission's "Data on Dams in New Hampshire" (March 29, 1939); the New Hampshire Water Resources Board's "Inventory of Dams and Water Power Developments" (July 5, 1935); and the Public Service Commission of New Hampshire's "Dam Record" (August 27, 1935). Inspection reports dated June 13, 1940; July 5, 1951; and July 19, 1974 are also available.

However, since the dam was completely reconstructed in 1966, most of the earlier information is not useful. Most of the basic data available are from the plans for this reconstruction. There is also a 1974 letter from the New Hampshire Water Resources Board to the Town of Milford concerning repairs needed at the dam.

More recent data includes a 1977 Flood Insurance Study by Anderson-Nichols and Company, Inc. (ANCO) which covers this portion of the Souhegan River. This work includes 10, 50, 100, and 500-year peak flows; cross-section data at various points on the Souhegan River (including the dam and bridge just upstream); and backwater calculations (using the WSP-2 computer program) for selected flows.

The appropriate hazard classification for this dam is LOW. Failure of Milford Town Dam would cause an increase in downstream water surface elevation of 0.5 foot or less. It is unlikely that failure of Milford Town Dam would cause loss of life or serious economic damage.

As shown in Table 3 of the Corps of Engineers' "Recommended Guidelines," the appropriate Test flood for a dam classified as SMALL in size with a LOW hazard potential would be between the 50-year flow and the 100-year flow. The ANCO Flood Insurance Study gives a 50-year flow of 8850 cfs and a 100-year flow of 10,500 cfs at the dam. Since the hazard classification is on the low side of LOW, the 50-year flow of 8850 cfs is appropriate for use as the Test Flood for this dam. The peak water surface elevation created by the flow of 8850 cfs would be 241.4 feet MSL or 6.2 feet above the spillway, 1.0 foot above the left abutment structure, and 0.6 foot below the right intake structure. Thus, the spillway is inadequate to pass the test flood. The spillway capacity is 6870 cfs which is 78 percent of the test flood flow.

The estimated flow from the 1936 flood is 14,400 cfs at the dam site. This would have created a water surface 8.6 feet above the present spillway crest or 3.4 feet above the left abutment structure.

Milford Town Dam would be overtopped by the Test Flood, which is the 50-year flow. However, it would appear from the hydraulics of this low head dam that high flows would result in submergence of the dam. If the dam were to fail when the water surface elevation reaches the top of the dam, the flow would increase by roughly ten percent while the stage downstream would increase by about 0.5 feet.

(f) Dam Failure Analysis

The peak outflow that would result from the failure of Milford Town Dam is estimated using the procedure suggested in the Corps of Engineers New England Division's April 1978 "Rule of Thumb Guidelines for Estimating Downstream Dam Failure Hydrographs," as expanded on at a December 7, 1978 meeting. Failure is assumed to occur with the water surface elevation at the top of the left abutment (5.2 feet above the spillway crest) at an elevation of 240.4 feet above Mean Sea Level (MSL).

The discharge prior to failure with the water level at the dam crest (5.2 feet above the spillway) would be 6870 cfs as determined from the Stage-Discharge curve developed as described in Appendix D. The tailwater prior to failure would be 236.4 feet MSL, 1.2 feet above the spillway crest.

With a seventy-foot gap opened in the spillway, dam failure would cause flow to increase by 940 cfs to 7720 cfs. This would cause the tailwater to rise 0.5 foot to 236.9 feet MSL. This small rise would not cause a significant increase in downstream flooding, and would be quickly attenuated.

SECTION 6 - STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

(a) Visual Observations

The field investigations revealed no significant displacement and/or distress that would warrant the preparation of structural stability calculations based on assumed sectional properties and engineering factors.

(b) Design and Construction Data

No stability calculations are available for this dam. The plans show several design cross sections but no as-built cross sections are available.

(c) Operating Records

No operating records are available for the dam.

(d) Post Construction Changes

Since the reconstruction of the dam in 1966, no changes have been made.

(e) Seismic Stability

The dam is located in Seismic Zone No. 2 and, in accordance with recommended Phase I guidelines, does not warrant seismic analysis.

SECTION 7 - ASSESSMENT, RECOMMENDATIONS, AND REMEDIAL MEASURES

7.1 Dam Assessment

(a) Condition

Milford Town Dam is in FAIR condition at the present time. The spillway and left abutment structure are in good condition while the right intake structure is in poor condition.

(b) Adequacy of Information

The lack of in-depth engineering data does not permit a definitive review. Therefore, the adequacy of the dam cannot be assessed from the standpoint of reviewing design and construction data. This assessment is thus based primarily on the visual inspection, past performance, and sound engineering judgment.

(c) Urgency

The engineering studies and improvements described herein should be implemented by the owner within one year of receipt of this Phase I report.

(d) Need for Additional Investigation

Additional investigations are required as described in Paragraph 7.2.

7.2 Recommendations

It is recommended that the owner retain a registered professional engineer to determine if the right intake structure is adequately sealed. Appropriate remedial measures should be taken following the investigation.

7.3 Remedial Measures

The following remedial measures should be instituted by the owner:

(1) Repair the deteriorated concrete on the right intake structure.

(2) Monitor by visual observation the seepage at the base of the intake structure and building for changes in flow quantity or turbidity which may require remedial action.

(3) Repair the concrete on the right upstream training wall.

(4) Repair the concrete on the right downstream training wall.

(5) Remove trees and other brush growing between the two downstream training walls.

(6) Institute a program of annual technical inspections.

7.4 Alternatives

There are no meaningful alternatives to the above recommendations and improvements.

APPENDIX A

VISUAL INSPECTION CHECKLIST

INSPECTION TEAM ORGANIZATION

Date: November 1, 1978

NH 00312
MILFORD TOWN DAM
Milford, New Hampshire
Souhegan River
NHWRB 159.03

Weather: Clear, 55° F ±

INSPECTION TEAM

Nicholas Campagna	Goldberg, Zoino, Dunnicliff & Associates, Inc. (GZD)	Team Captain
Robert Minutoli	GZD	Soils
Andrew Christo	Andrew Christo Engineers, Inc. (ACE)	Structural
Paul Razgha	ACE	Concrete
Guillermo Vicens*	Resource Analysis, Inc.	Hydrology

*Mr. Vicen's site inspection was made on November 8,1978.

CHECK LISTS FOR VISUAL INSPECTION

AREA EVALUATED	BY	CONDITION & REMARKS
DAM SUPERSTRUCTURE		
A. General		
Vertical alignment and movement	AC	No deficiencies noted
Horizontal alignment and movement		No deficiencies noted
B. Left End Wall		
Condition of concrete		Good
Spalling		None noted
Erosion		None noted
Cracking		None noted
Rusting or staining of concrete		None noted
Visible reinforcing		None noted
Efflorescence		None noted
Seepage		None noted
C. Upstream Training Walls		
Right bank		
Stone masonry		Ten foot section adjacent to concrete wall settled. Open joints 3' high. Random fill placed in front of wall. Balance of wall does not show any evidence of distress
Efflorescence		Mortared joints highly effloresced
Concrete	AC	Poor. Interface with supported stone masonry is eroded up to 12" deep

CHECK LISTS FOR VISUAL INSPECTION

AREA EVALUATED	BY	CONDITION & REMARKS
C. Upstream Training Wall- (cont.)		
Left bank		
Stone masonry	A C	No deficiencies noted with the exception of minor joint efflorescence
D. Downstream Training Walls		
Right Bank		
Cemented stone masonry		No deficiencies noted with the exception of minor joint efflorescence
Dry stone masonry		Slightly unravelled
Concrete		Poor. Series of horizontal cracks with associated efflorescence. No other deficiencies noted
Tailrace training wall		Destroyed
Vegetation		Trees up to 4" dia. and brush flourishing in interface between dry and cemented stone masonry walls
Left Bank		
Dry stone masonry	P C	Fair. No visible signs of distress
OUTLET WORKS		
A. Left Abutment Structure	PR	
Condition of concrete		Good
Spalling	PR	None noted

CHECK LISTS FOR VISUAL INSPECTION

AREA EVALUATED	BY	CONDITION & REMARKS
Erosion	PR	None noted
Cracking		None noted
Rusting or staining of concrete		None noted
Visible reinforcing		None noted
Efflorescence		None noted
Seepage		None noted
Condition of dry stone masonry		Good
Stop logs		Good
B. Spillway		
Condition of concrete		Good
Spalling		None noted
Erosion		Minor at downstream base
Cracking		None noted
Rusting or staining of concrete		None noted
Visible reinforcing		None noted
Efflorescence		None noted
Seepage		None noted
C. Right intake structure		
Condition of concrete	RR	Poor

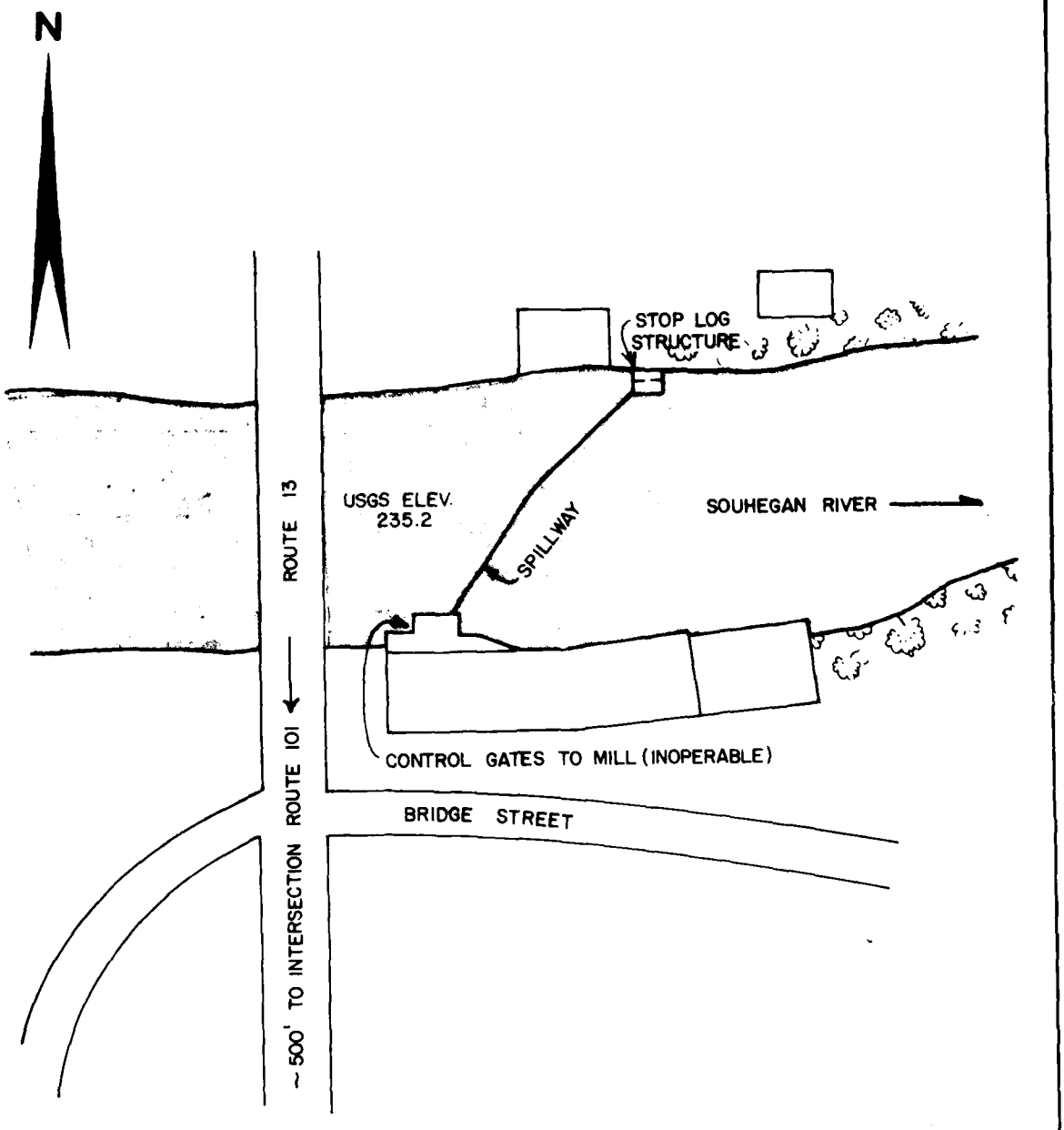
CHECK LISTS FOR VISUAL INSPECTION

AREA EVALUATED	BY	CONDITION & REMARKS
Spalling	PL	Intermediate pier and downstream wall spalled over 10% of surface area, roof spalled over 50% of its surface area
Erosion		Over a vertical height of 2' starting at spillway crest level
Cracking		Continuous horizontal crack on downstream face, 3' above spillway crest level
Rusting or staining of concrete		None noted
Visible reinforcing		None noted
Efflorescence	PR	At horizontal crack
Seepage	NAC	Under foundation of old mill building 8 feet downstream of the spillway at the rate of 4 to 8 gpm
Condition of gates	FC	Inoperable
Gates		Rotted
Operating equipment		Inoperable
Stop logs		Good
Trash racks	FC	Rusted; one panel missing from upstream intake
RESERVOIR		
A. Shoreline		
Evidence of slides	NAC	None noted
Potential for slides		Shoreline stable
B. Sedimentation	NAC	Leaves and silt behind spillway

CHECK LISTS FOR VISUAL INSPECTION

AREA EVALUATED	BY	CONDITION & REMARKS
C. Debris	NAC	Temporary debris along crest of spillway; will be washed away when flow increases
D. Upstream Hazard Areas in Event of Backflooding		None noted
E. Changes in Nature of Watershed		None noted
DOWNSTREAM CHANNEL		
A. Trees Overhanging Channel		Several trees up to 4 inch diam. and brush overhanging right side on the downstream training wall
B. Channel Bottom		Bedrock exposed at toe of spillway
OPERATION AND MAINTENANCE FEATURES		
A. Reservoir Regulation Plan		
Normal procedures		Stop logs are maintained at spillway crest elevation
Emergency Procedures		Stop logs can be pulled to lower reservoir level
Compliance with designated plan		No operations have been performed
B. Maintenance		
Quality		Does not appear to have been any maintenance since dam was rebuilt in 1966
Adequacy	NAC	Situation requires a regular maintenance program

APPENDIX B



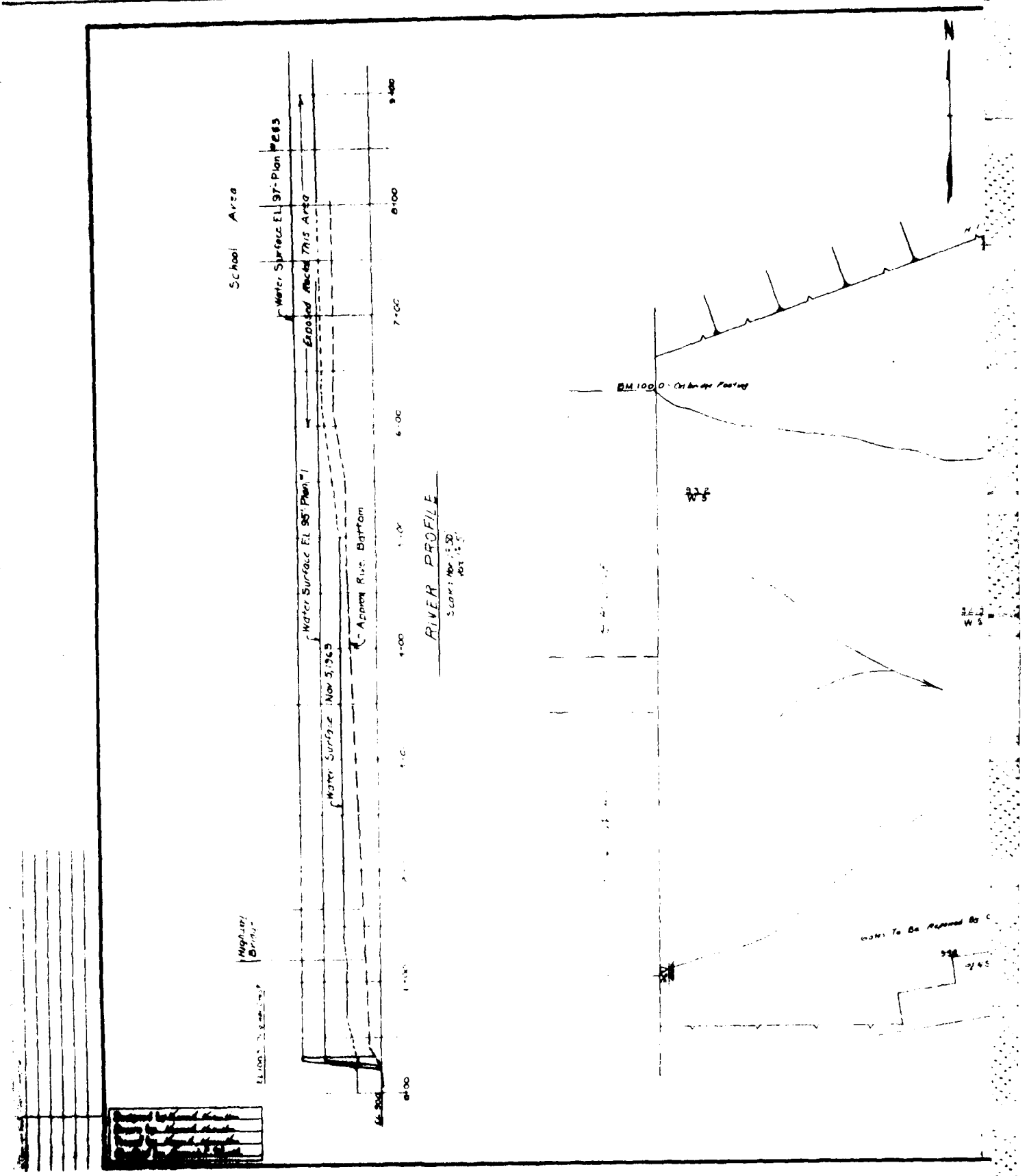
GOLDBERG, ZOINO, DUNNICLIFF & ASSOC., INC. GEOTECHNICAL CONSULTANTS NEWTON UPPER FALLS, MASS.	U.S. ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS.

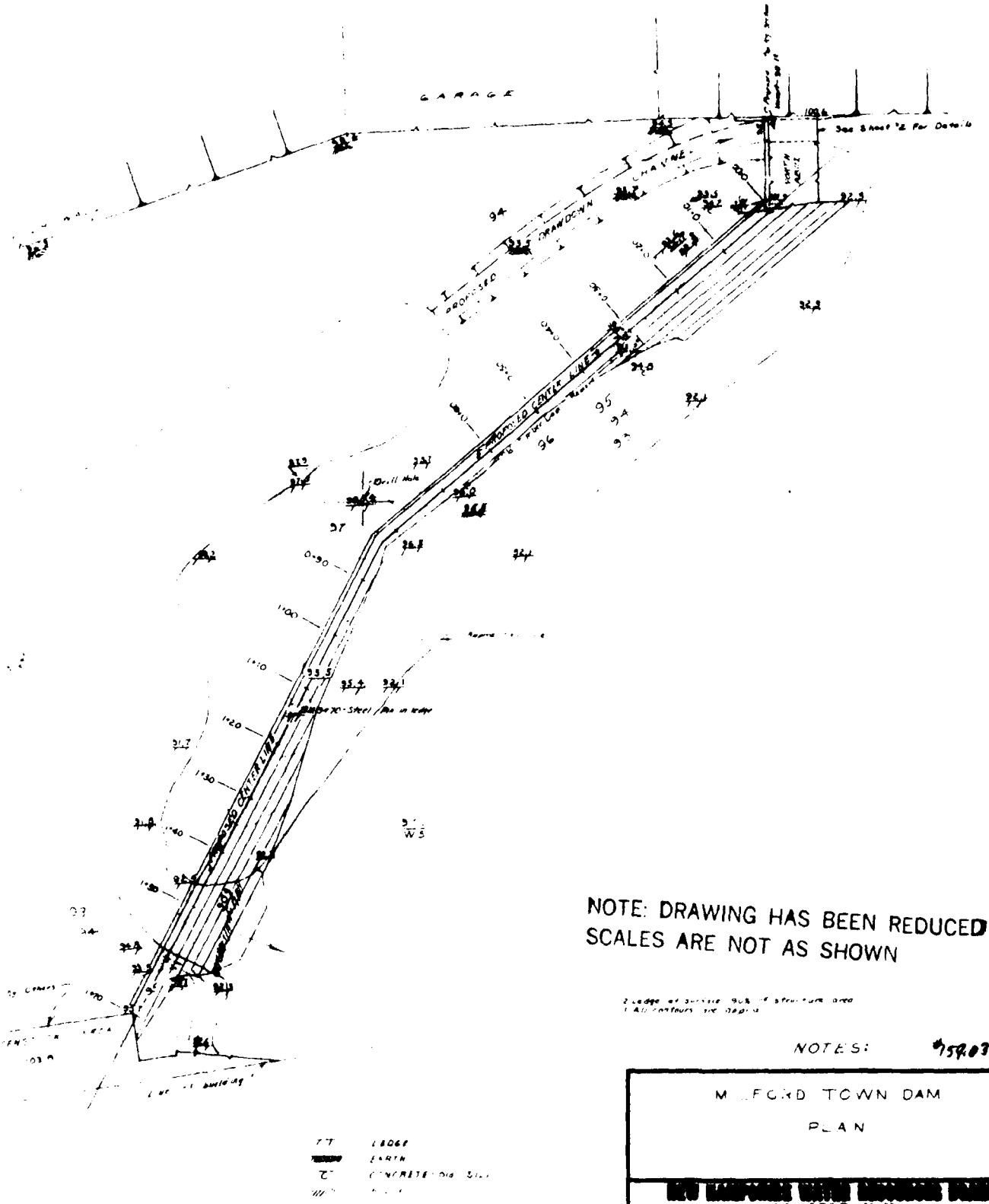
NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

SITE PLAN

MILFORD TOWN DAM — NEW HAMPSHIRE

SCALE	1" ≈ 100'
DATE	NOVEMBER 1978





NOTE: DRAWING HAS BEEN REDUCED
SCALES ARE NOT AS SHOWN

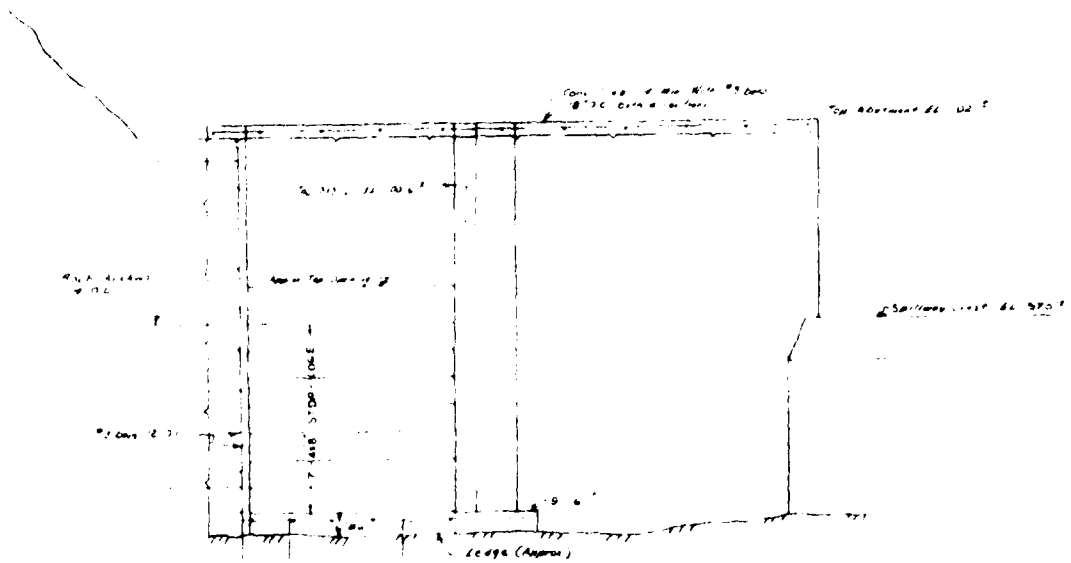
NOTES:

MILFORD TOWN DAM

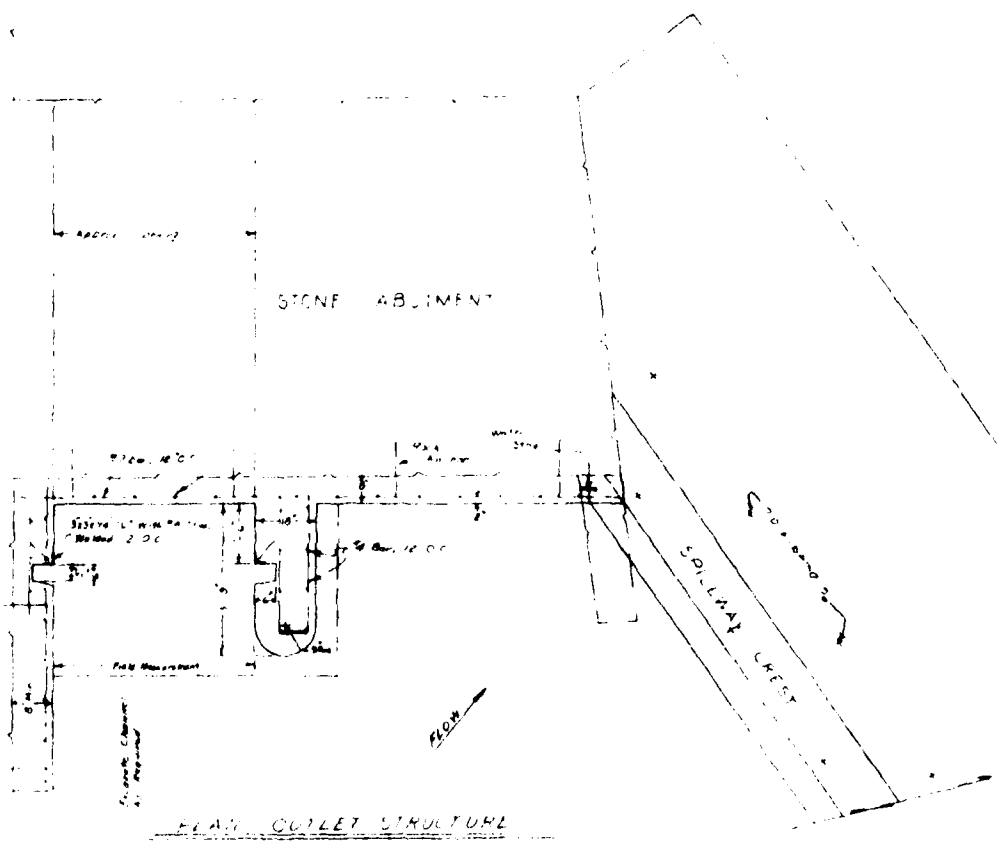
PLAN

[redacted] - CONCORD, N. H. -

SCALE	SHEET	DATE
1" = 10'	SHEET 1 OF 3 SHEETS	JAN 29 19[redacted]



ELEVATION - OUTLET STRUCTURE



PLAN OUTLET STRUCTURE

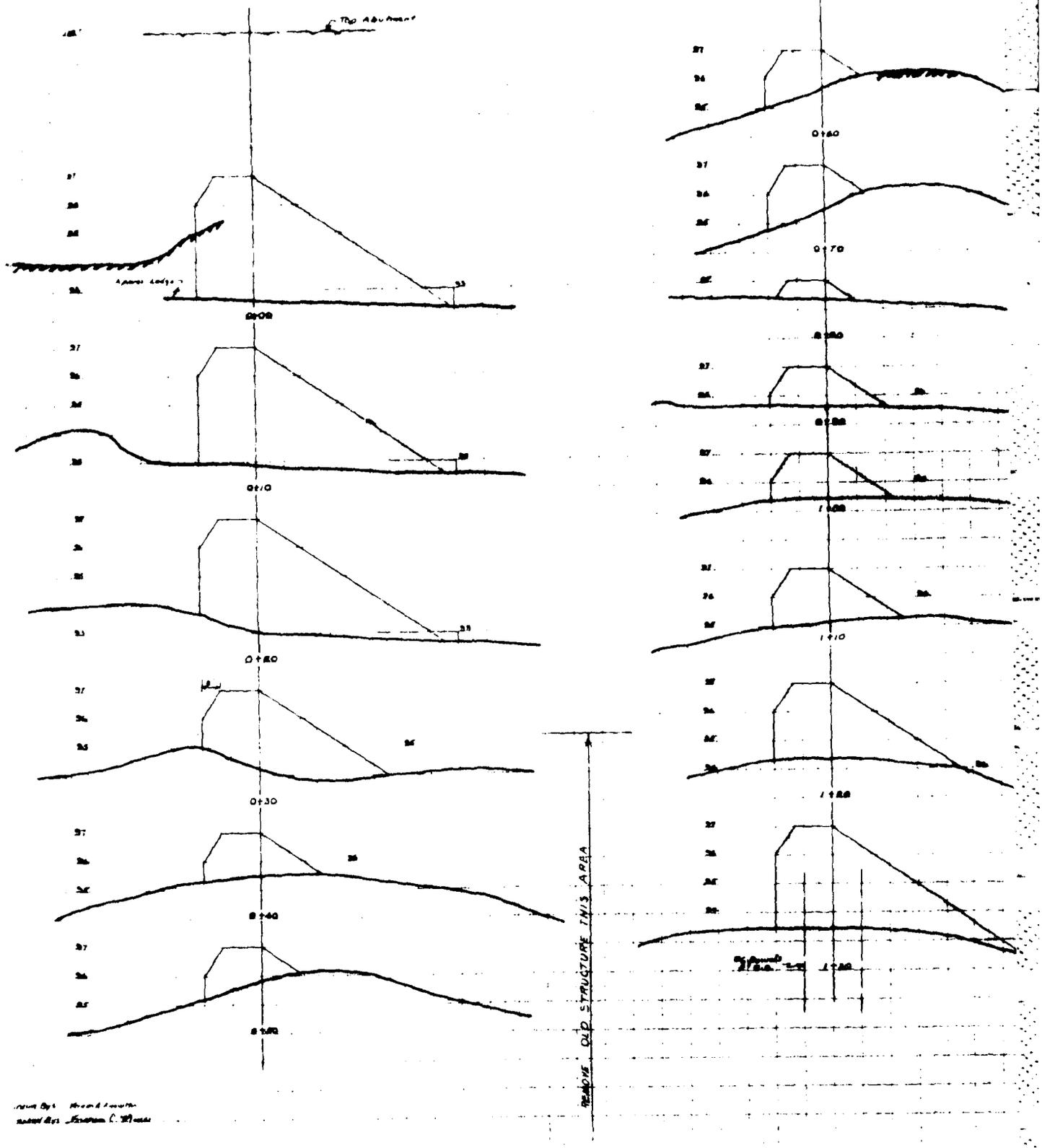
Designed by
Drawn by
Traced by
Checked by

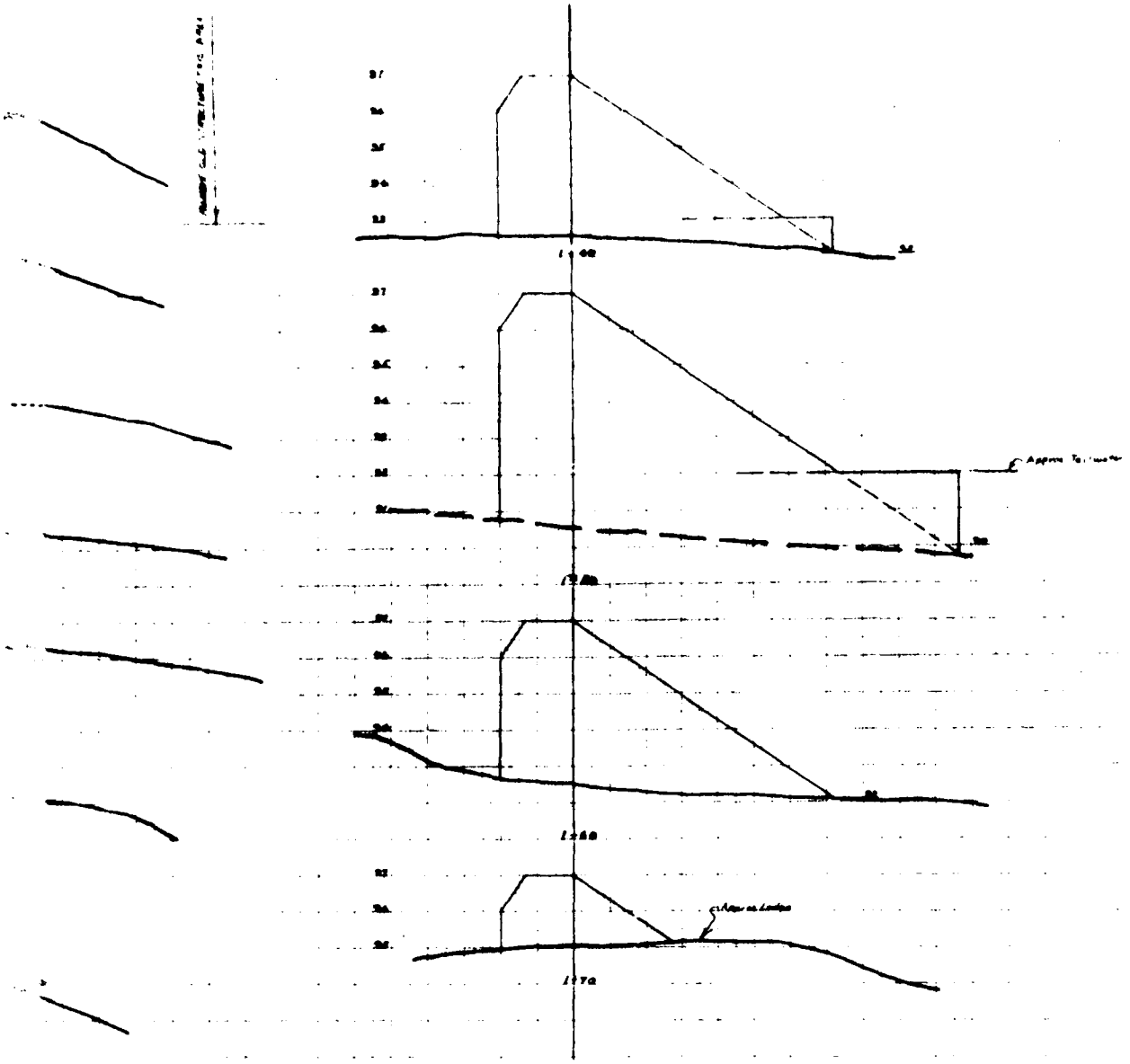
NOTE: DRAWING HAS BEEN REDUCED
SCALES ARE NOT AS SHOWN
2/5/03

[illegible] TOWN DAM

DETAILS

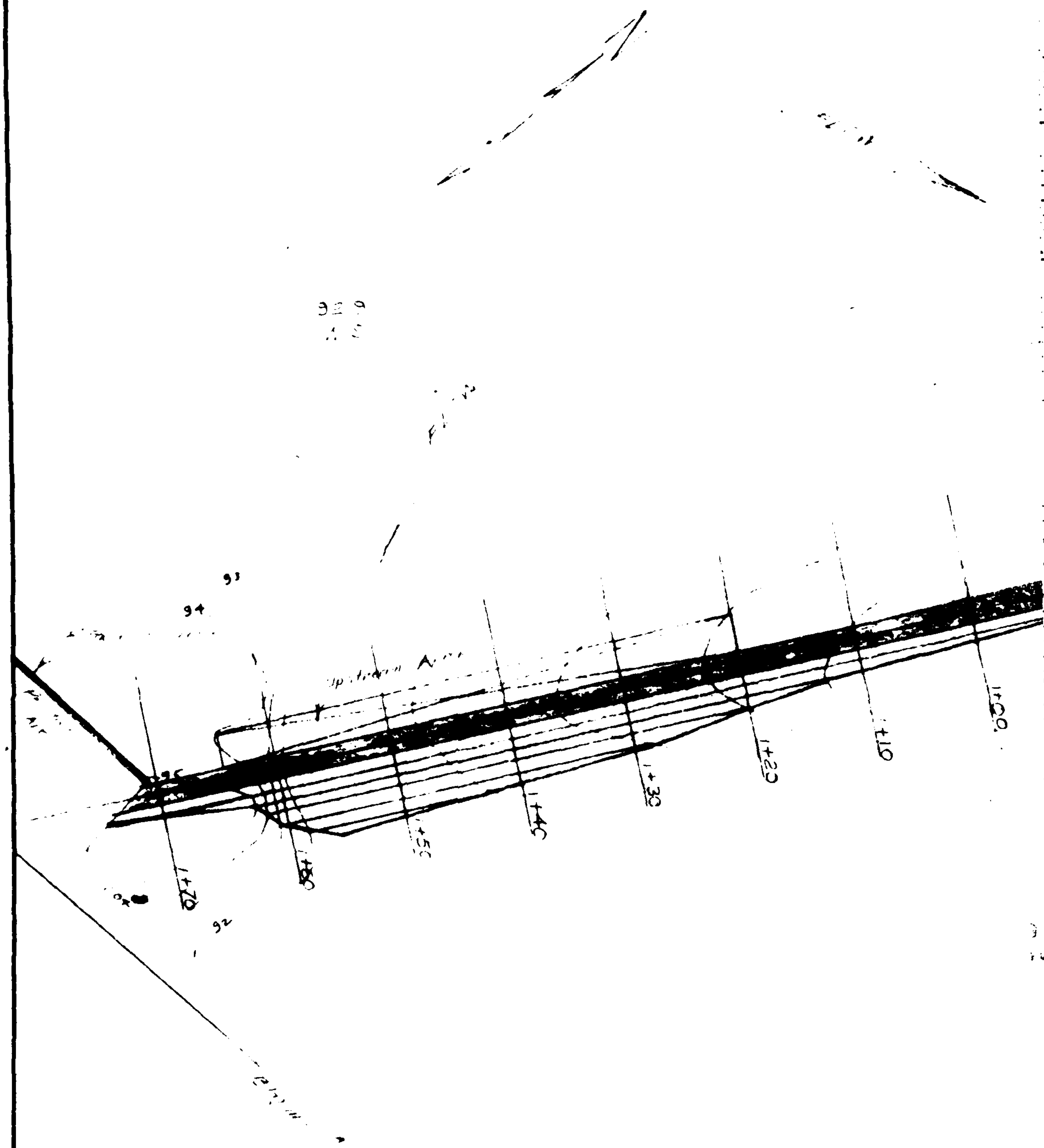
NEW HAMPSHIRE WATER RESOURCES BOARD
- CONCORD, N. H. -





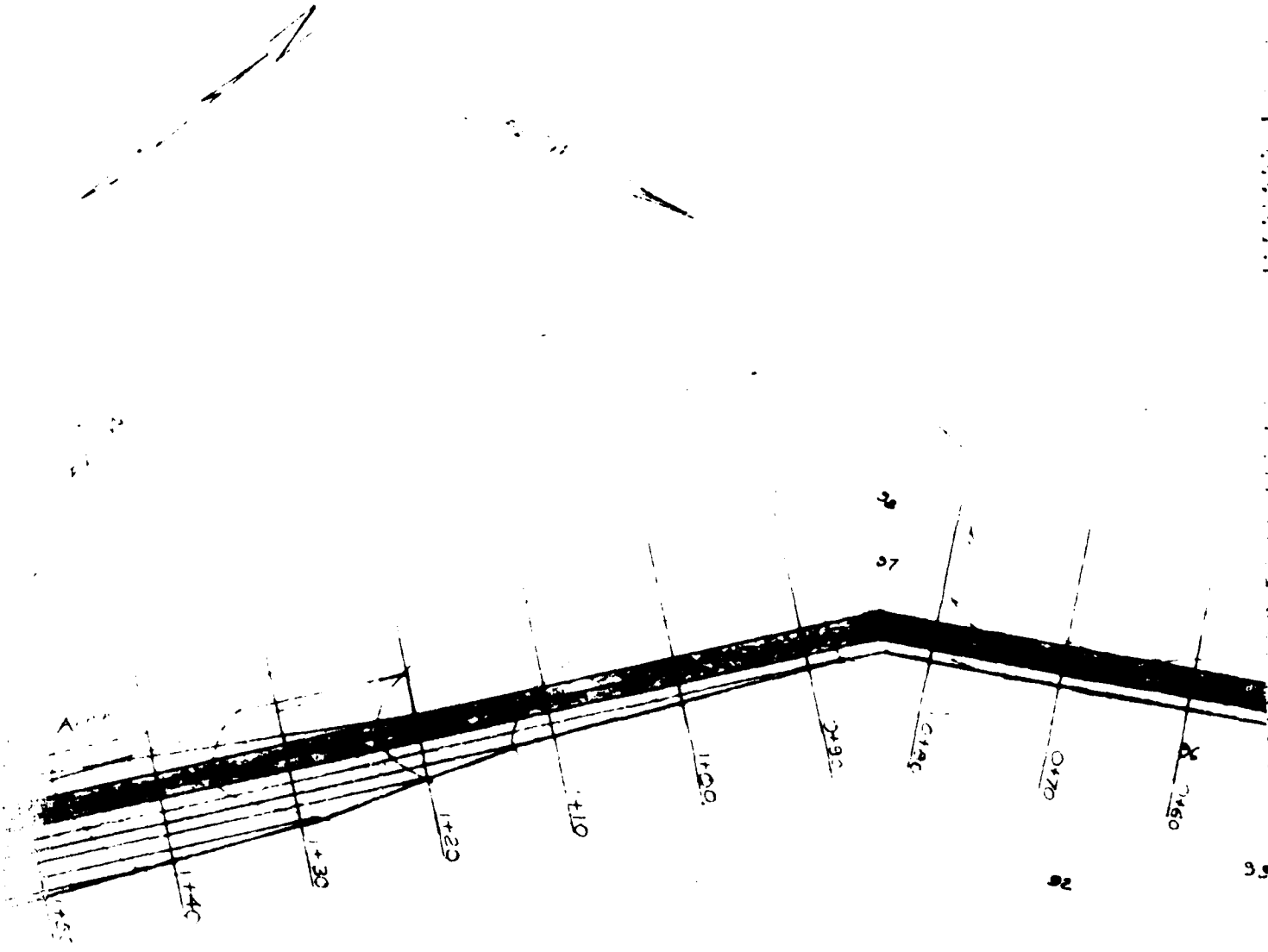
NOTE: DRAWING HAS BEEN REDUCED
SCALES ARE NOT AS SHOWN

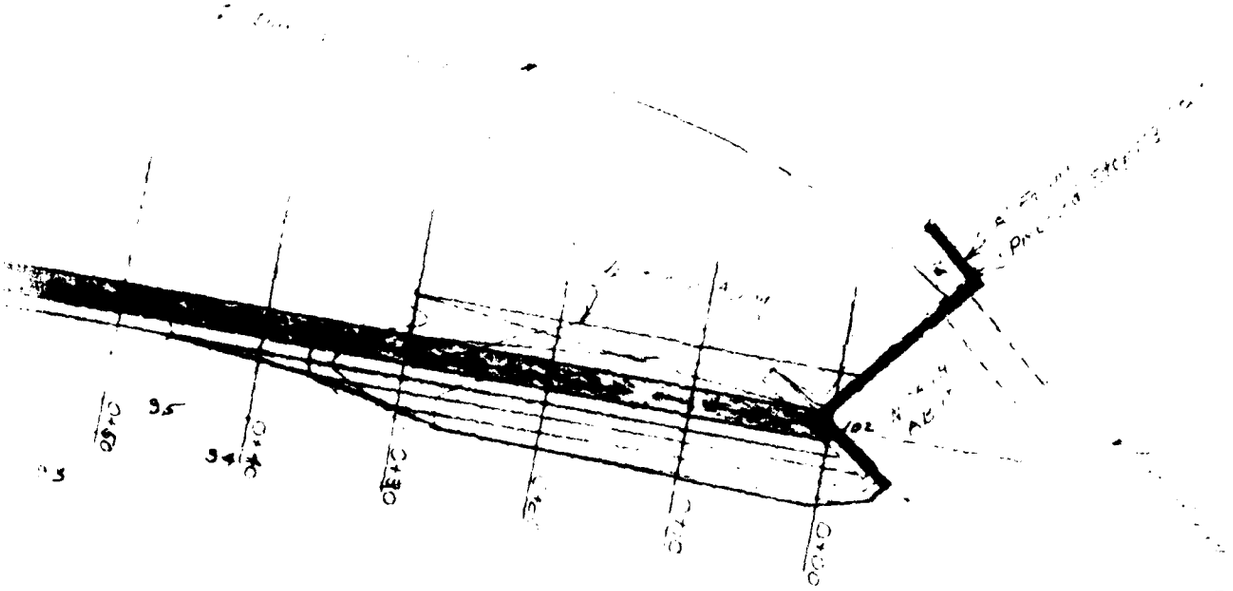
MILFORD TOWN DAM
SECTIONS



DRAWN BY

CHECKED BY





NOTE: DRAWING HAS BEEN REDUCED
SCALES ARE NOT AS SHOWN 15703

[illegible] POND TOWN DAM
DAM [illegible]
POOL [illegible] 97.0
PLAN &

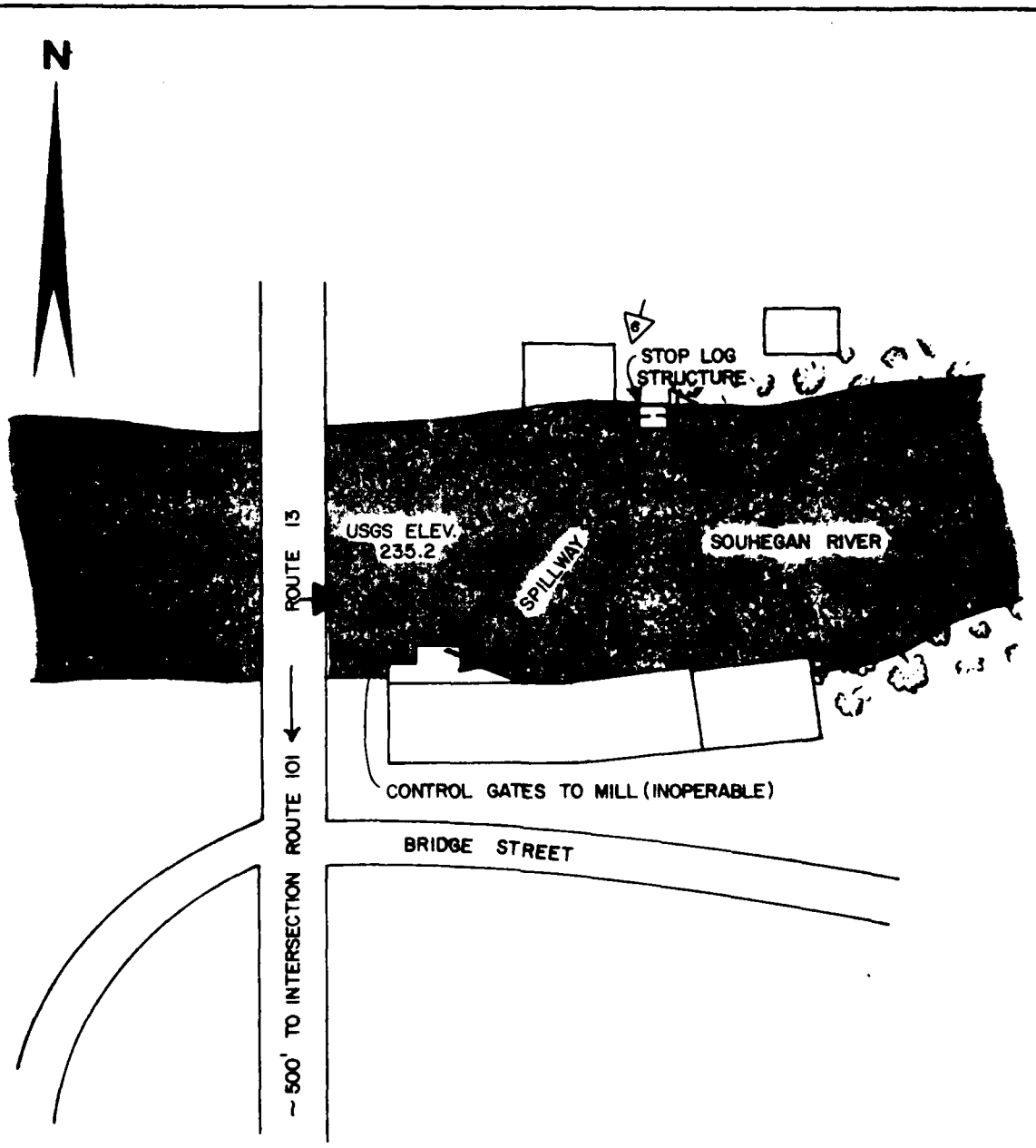
NEW HAMPSHIRE
WATER RESOURCES BOARD
CONCORD, N. H.

1" = 5'	SHEET 5 OF 8 SHEETS	[illegible]

The New Hamsphire Water Resources Board (NHWRB), 37 Pleasant Street, Concord, N.H. 03301, maintains a correspondence file on the dam including prior inventory and inspection reports. Most of these reports pertain to the previous dam existing at the site and not the present dam although there is an inspection report for a 1974 inspection at the dam.

APPENDIX C

SELECTED PHOTOGRAPHS



OVERVIEW

APPENDIX C

GOLDBERG, ZOINO, DUNNICLIFF & ASSOC., INC.
GEOTECHNICAL CONSULTANTS
NEWTON UPPER FALLS, MASS.

U.S. ARMY ENGINEER DIV. NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

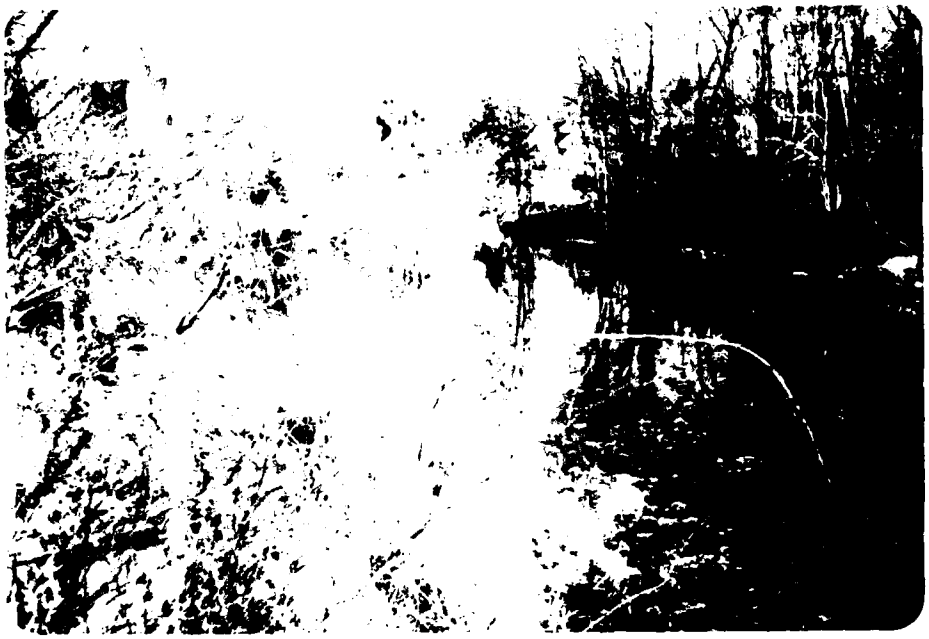
LOCATION AND ORIENTATION OF PHOTOS

FILE No. 2201

MILFORD TOWN DAM — NEW HAMPSHIRE

SCALE 1" = 100'

DATE NOVEMBER 1978



1. View of downstream channel from left abutment

2. View from upstream road bridge showing abandoned inlet structure

3. View from gate structure of seepage between bedrock and old mill building wall

4. View of sluiceway from downstream channel

5. View of old mill building from left abutment showing old discharge channel from power plant in building

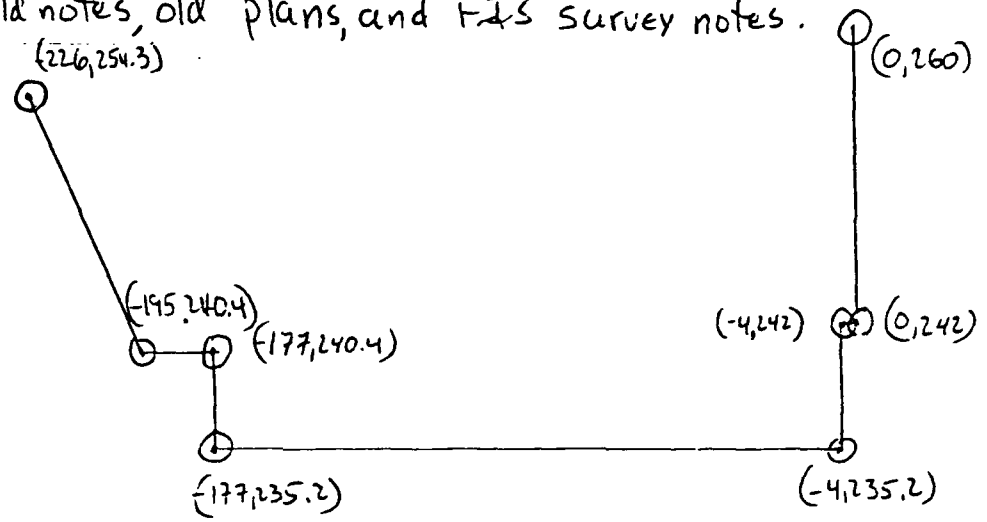
6. Overview of dam from left abutment

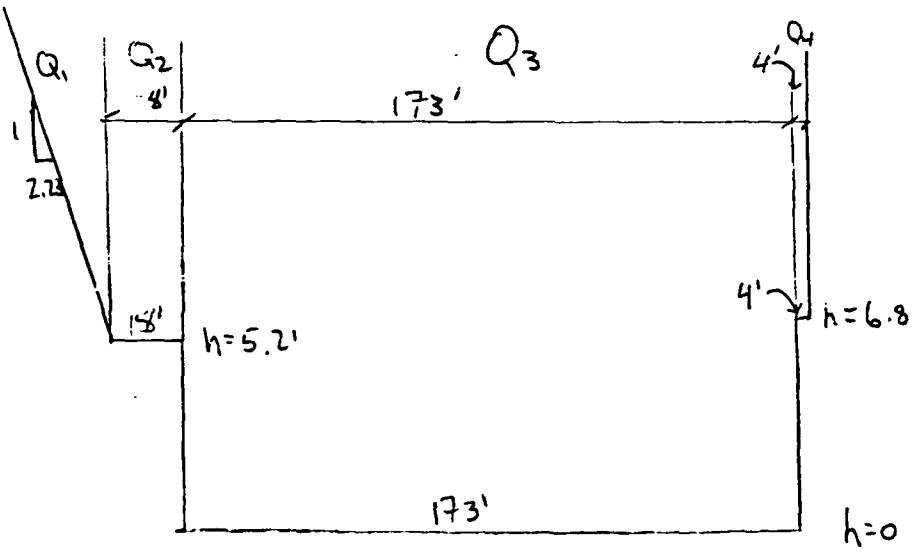
APPENDIX D

HYDROLOGIC/HYDRAULIC COMPUTATIONS

Stage-Discharge Curve.

The information used to establish the cross-section at Milford Town Dam was determined from field notes, old plans, and FIS survey notes.





Flow through the gate is considered to be negligible, as the gate is almost closed by stoplogs, and there is no established procedure for operation in a storm.

for $h = 0$ to 5.2

$Q_3 = 3.3\ (173)\ h^{3/2}$

$Q_1 = Q_2 = Q_4 = 0$

At our flows of interest, dam is a sharp-crested weir, C = 3.3

$h = 5.2$ to 6.8

$Q_1 = 2.8(2.23)(h-5.2)(.5(h-5.2))^{3/2}$

$Q_2 = 3.0\ (18)\ (h-5.2)^{3/2}$

Broad-crested earth weir, C = 2.8

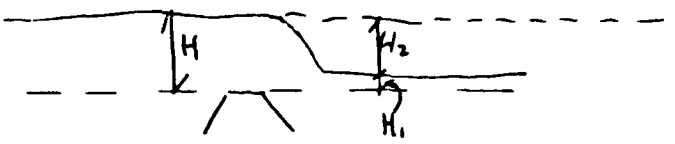
Broad-crested concrete weir, C = 3.0

$h = 6.8$ up

$Q_4 = 3.0\ (4)\ (h-6.8)^{3/2}$

Tailwater Submergence

At high flows the tailwater on the Souhegan River submerges the spillway at Milford Town Dam. This tailwater submergence reduces flow over the spillway. The Bureau of Reclamation's Design of Small Dams, figure 254 gives a plot of the reduction factor for an ogee spillway. Reduction for a sharp-crested weir is similar. The reduction depends on H_2/H, with H_2 and H as defined in this sketch:



The relationship in Figure 254 for $H_2/H_1 \geq .15$ can be approximated:

C_1 = reduction factor = 1.0 for $H_2/H \geq .7$

$C_1 = 1.063 - .04096\left(H/H_2\right)$ $\quad .15 \leq H_2/H \leq .7$

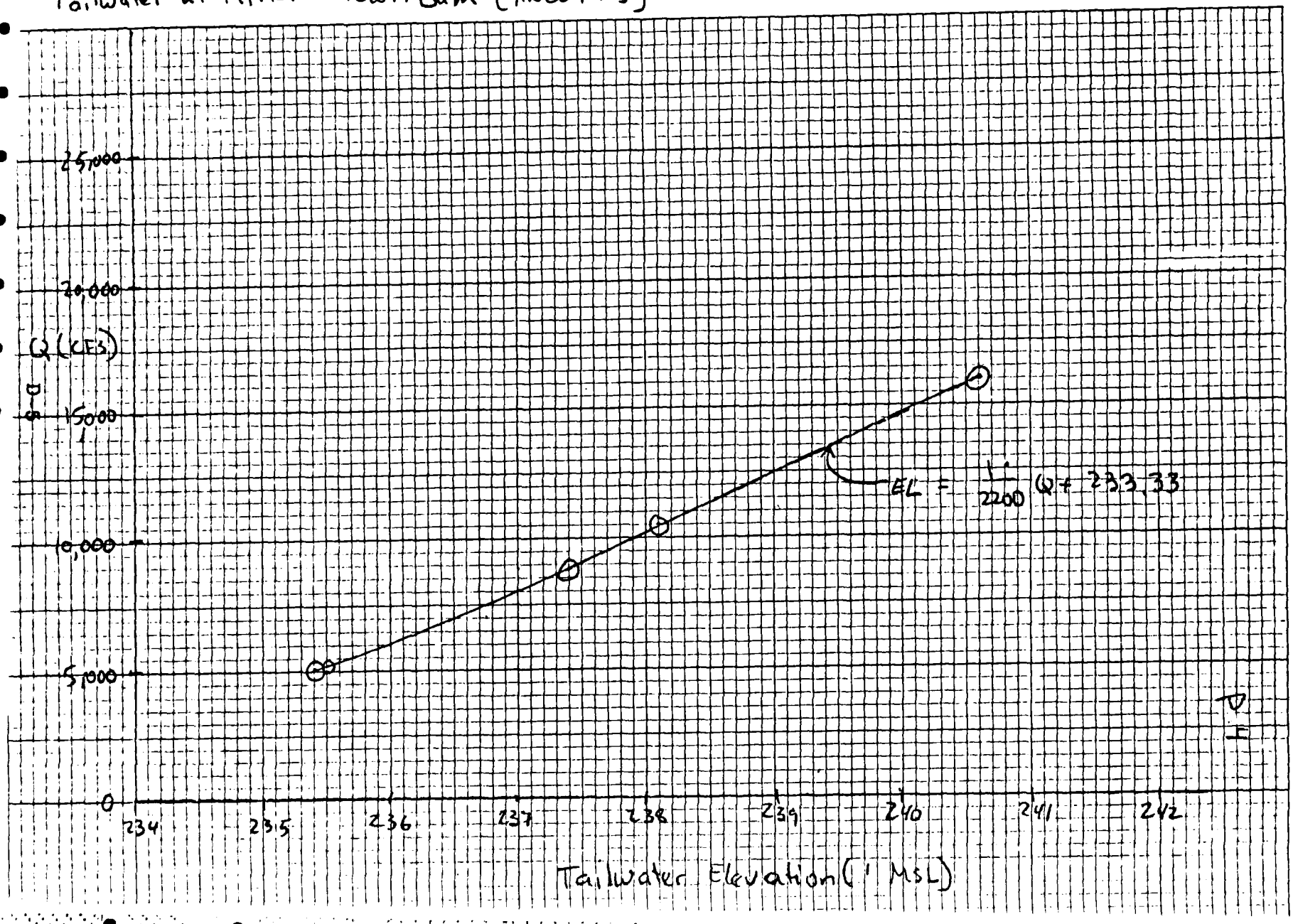
$H_2 = H - H_1$ (see sketch, p. 2), where H_1 is taken from a linear estimated based on ANCO WSP-2 runs (see p. 4):

$$H_1 = \frac{1}{2200} Q + 233.33 - 235.2$$

$$= 1/2200\, Q - 1.87$$

If $H_1 \leq 0$, there is no reduction (water is below the spillway). If $H_1 > 0$, the reduction factor applies. A BASIC subroutine to calculate the reduction factor (C_1) is in lines 380-540 of the Stage-Discharge calculation program on pp. 5-8

Tailwater at Milford Town Dam (ANCO FIS)



```
LIST
100 REM: STAGE DISCHARGE PROGRAM FOR MILFORD TOWN DAM, JOB 165
110 REM: ON TAPE 10, FILE 61
120 C1=1
130 PAGE
140 PRINT "DISCHARGE FROM MILFORD TOWN DAM AS A FUNCTION OF HEAD"
150 PRINT USING 160:
160 IMAGE // 2T"HEAD"30T"DISCHARGE"
170 PRINT USING 180:
180 IMAGE 1T"(FEET)"32T"(CFS)"
190 PRINT USING 200:
200 IMAGE 15T"C1"5X"TOTAL"5X"LEFT BANK"5X"RIGHT BANK"5X "SPILLWAY"
210 FOR H=0 TO 14 STEP 0.5
220 Q1=0
230 Q2=0
240 Q4=0
250 Q3=3.3*173*H↑1.5
260 IF H<=5.2 THEN 310
270 Q1=2.8*2.23*(H-5.2)*(0.5*(H-5.2))↑1.5
280 Q2=3*18*(H-5.2)↑1.5
290 IF H<=6.8 THEN 310
300 Q4=3*4*(H-6.8)↑1.5
310 T1=Q1+Q2
320 T3=T1+Q4+Q3
330 GOSUB 380
340 PRINT USING 350:H,C1,T3,T1,Q4,Q3
350 IMAGE 1T,2D.2D,8D.2D,10D,12D,15D,14D
360 NEXT H
370 END
380 C1=1
390 I1=0
400 Q3=C1*3.3*173*H↑1.5
410 C2=C1
420 T3=T1+Q4+Q3
430 I1=I1+1
```

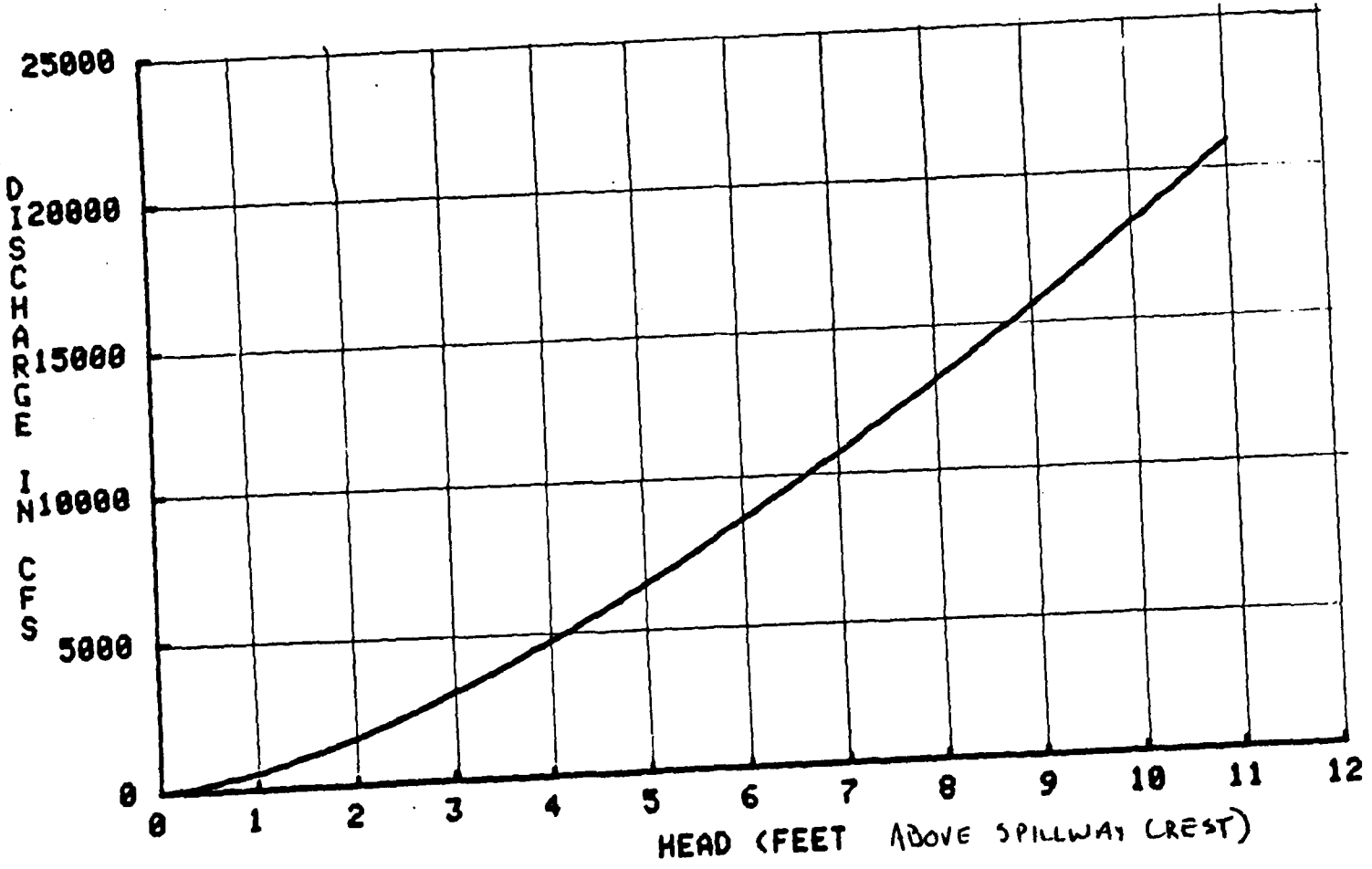

P.S.

```
440 H1=1/2200*T3+233.33-235.2
450 IF H1<=0 THEN 520
460 H2=H-H1
470 IF H2/H>0.7 THEN 530
480 C1=1.063-0.04096*H/H2
490 Q3=Q3*C1/C2
500 IF I1<15 THEN 400
510 T3=T1+Q4+Q3
520 RETURN
530 C1=1
540 RETURN
```

DISCHARGE FROM MILFORD TOWN DAM AS A FUNCTION OF HEAD

HEAD (FEET)	C1	TOTAL	DISCHARGE (CFS) LEFT BANK	RIGHT BANK	SPILLWAY
0.00	1.00	0	0	0	0
0.50	1.00	202	0	0	202
1.00	1.00	571	0	0	571
1.50	1.00	1049	0	0	1049
2.00	1.00	1615	0	0	1615
2.50	1.00	2257	0	0	2257
3.00	1.00	2966	0	0	2966
3.50	1.00	3738	0	0	3738
4.00	1.00	4567	0	0	4567
4.50	1.00	5450	0	0	5450
5.00	1.00	6383	0	0	6383
5.50	1.00	7373	9	0	7364
6.00	1.00	8447	40	0	8407
6.50	1.00	9518	84	0	9434
7.00	0.99	10630	140	1	10489
7.50	0.99	11781	206	7	11568
8.00	0.98	12965	282	16	12667
8.50	0.97	14178	367	27	13784
9.00	0.97	15416	462	39	14914
9.50	0.96	16673	566	53	16054
10.00	0.95	17947	679	69	17199
10.50	0.94	19232	802	85	18345
11.00	0.94	20526	933	103	19489
11.50	0.93	21823	1074	122	20627
12.00	0.92	23122	1224	142	21756
12.50	0.91	24417	1383	163	22871
13.00	0.90	25703	1551	185	23967
13.50	0.88	26941	1729	208	25004
14.00	0.86	27736	1917	232	25588

STAGE-DISCHARGE CURVE AT MILFORD TOWN DAM



Storage-Elevation Curve

The Storage-Elevation curve for Milford Town Dam is given on p. 10. This curve is based on a surface area of 8 acres and the assumption that the pond does not spread as it rises.

1" of runoff over 138 sq. mi.:

$$\rightarrow 1''(138)\left(\frac{640 \text{ acres}}{\text{sq. mi.}}\right)\left(\frac{1'}{12''}\right)$$

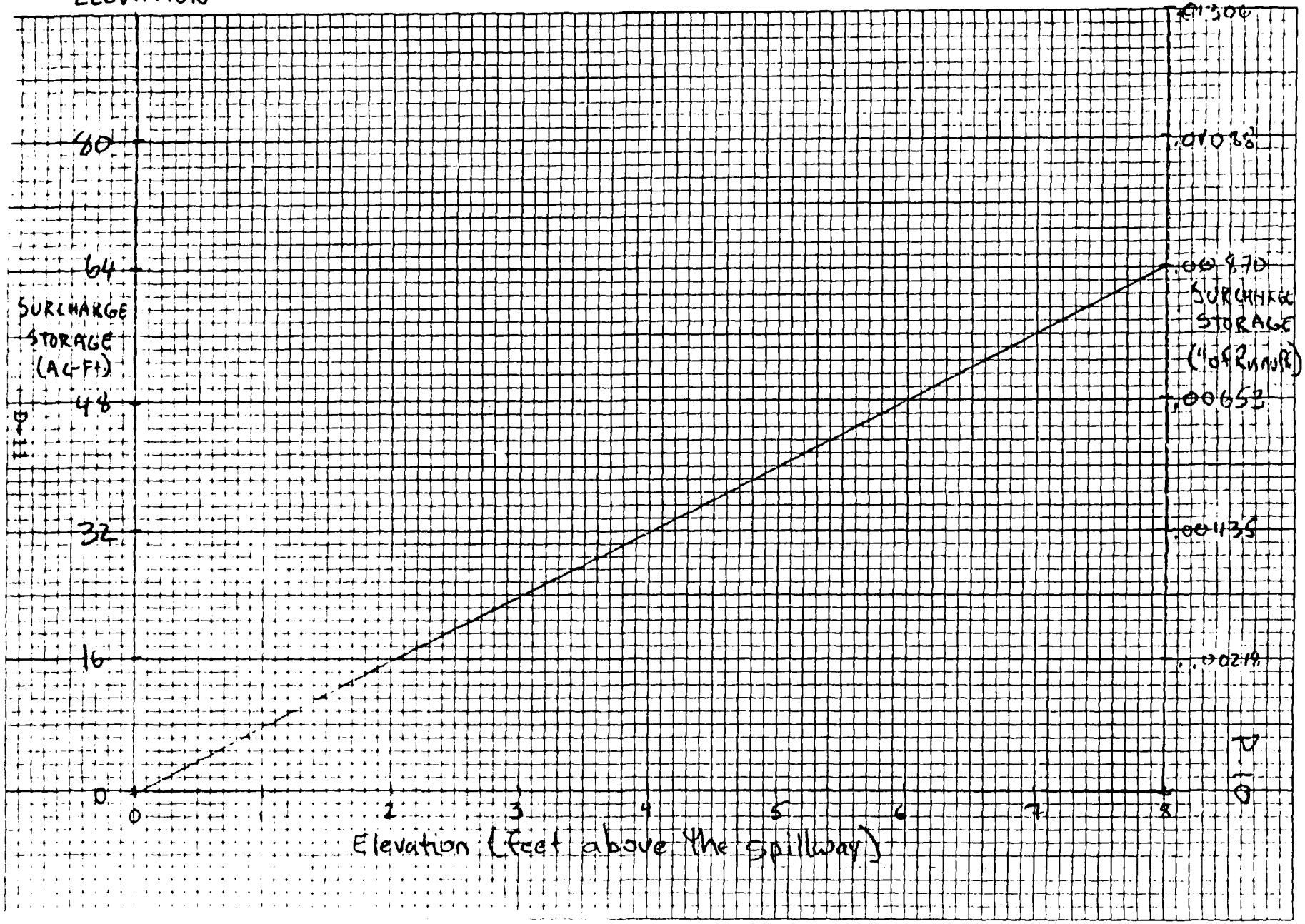
$$= 7360 \text{ Ac-Ft.}$$

1 Ac-Ft. Stores $\frac{1}{7360} = .000136''$ of runoff

1' rise will store $8.\text{ac}(1\text{ ft})\left(.000136''/\text{Aft}\right)$

$= .00109$ of runoff.

ELEVATION- STORAGE CURVE for Milford Town Dam



Dam Failure Analysis

- Assume that the dam fails when the water level reaches the left abutment, h = 5.2 (elevation 240.4). From the stage-discharge curve, this would require a discharge of 6780 cfs. The Tailwater Elevation curve on p. 4 indicates that this flow would create a tailwater elevation of 236.4' MSL.

Peak Failure Outflow = Normal outflow + Breach outflow

Normal outflow = 6780 cfs

Breach outflow = $Q_{p_1} = W_b \, 8/27 \sqrt{g} \; y_o^{3/2}$

y_o = height of water surface above tailwater

$= 240.4 - 236.4 = 4'$

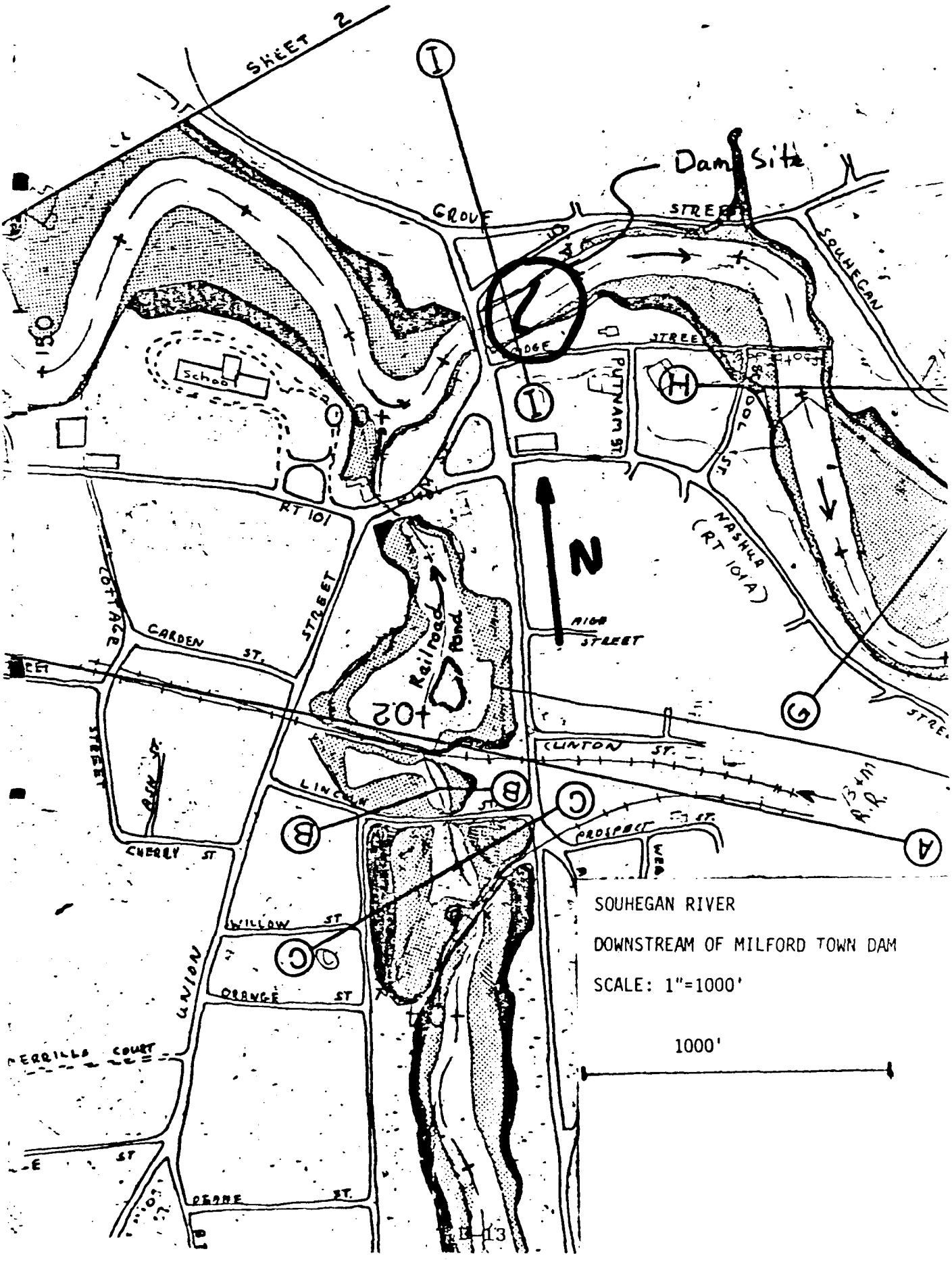
W_b = width of breach $\leq .4$ (width of dam)

$= .4 (173) = 70'$

$Q_{p_1} = 70 \left(\frac{8}{27}\right) \sqrt{g} \; 4^{3/2} = 940$ cfs

Peak outflow: 7720 cfs, which would increase the tailwater elevation .5', to 236.9' MSL.

p. 12 shows the path of the Souhegan River downstream of Milford Town Dam. An extensive analysis of the downstream dam failure hazard potential is not required, since the increase in flooding caused by dam failure is negligible at the dam, and would quickly attenuate downstream.


SHEET 2
Dam Site
GROVE STREET
SOUHEGAN
RIDGE STREET
PUTNAM ST
SCHOOL ST
School
RT 101
NASHUA (RT 101A)
N
HIGH STREET
Railroad Pond
CARDEN ST.
CLINTON ST.
LINCOLN ST.
PROSPECT ST.
CHERRY ST
WILLOW ST
ORANGE ST
UNION STREET
MERRILL COURT
PEARL ST.
SOUHEGAN RIVER
DOWNSTREAM OF MILFORD TOWN DAM
SCALE: 1"=1000'
1000'

TEST FLOOD ANALYSIS

Size Classification: Small

Hazard Classification: Low

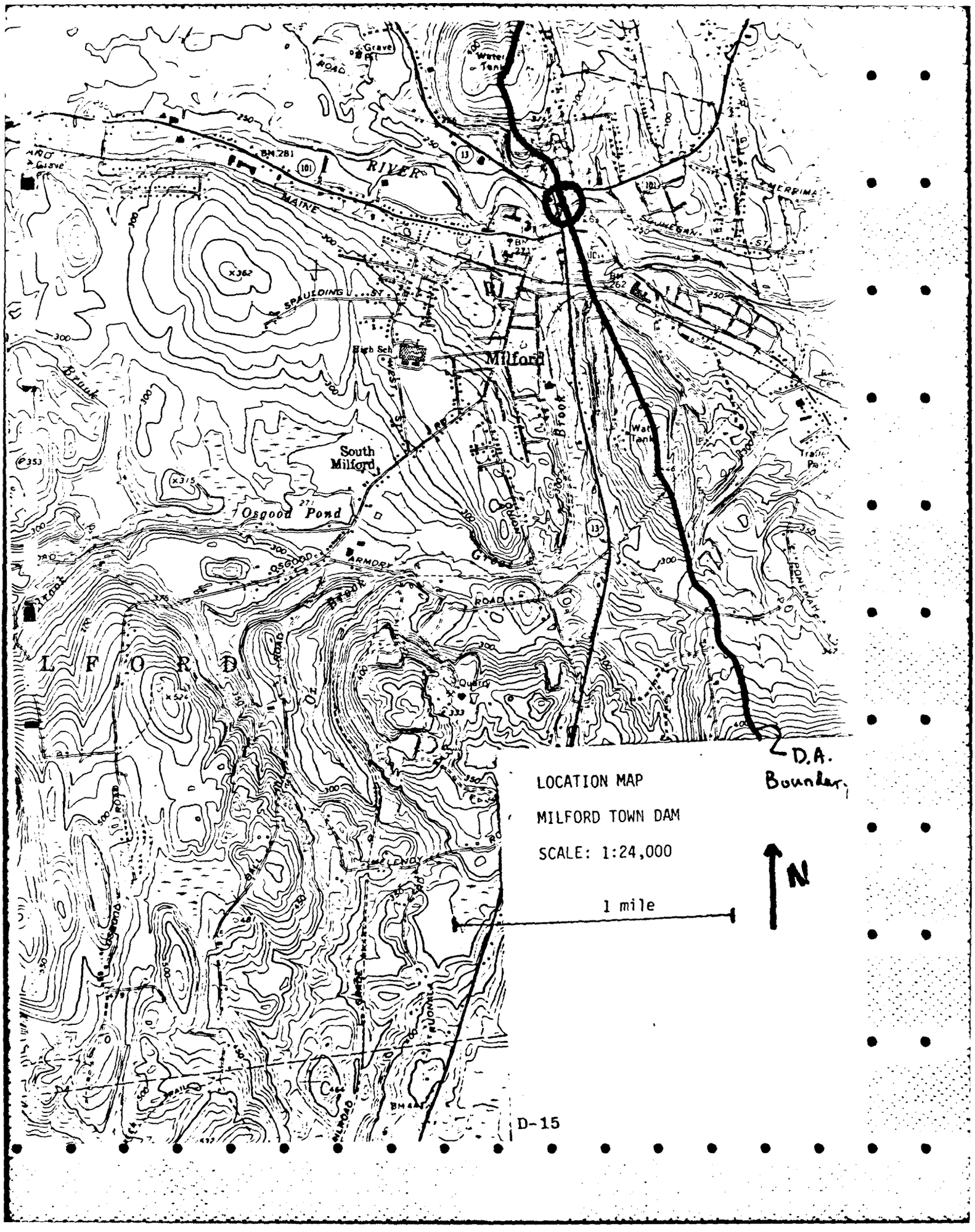
The hazard classification is low because the failure of Milford Town Dam would create little or no significant increase in downstream flooding. The failure would cause a rise of ½' or less in the downstream water surface.

Test Flood: 50 to 100 year

ANCO gives a fifty year flow at the dam of 8850 cfs. The 100 year flow is 10,500 cfs. Because the hazard is on the low side of low, we will use 8850 cfs. $\left(\frac{8850 \text{ cfs}}{138 \text{ sq. mi}} = 64.1 \text{ csm}\right)$

The flow of 8850 cfs would produce a stage about 6.2 feet above the spillway crest (1.0 feet above the left abutment, .6 feet below the right abutment, at elevation 241.4 MSL).

A map of Milford Town Dam's Location is shown on p. 14.


RIVER
MAINE
Milford
South Milford
Osgood Pond
SPAULDING
ARMORY
OSGOOD
ROAD
BROOK
L F O R D
D.A. Boundary
LOCATION MAP
MILFORD TOWN DAM
SCALE: 1:24,000
1 mile
N

Gage at Merrimack, New Hampshire (USGS)
Transposition of gauge peak discharge to dam site:

$$Q_s = Q_G \left(\frac{A_s}{A_G}\right)^T$$

A_s = drainage area at site
A_g = drainage area at gauge.

Assume T = .75 for New England

$$Q_s = 16{,}900 \left(\frac{138}{171}\right)^{.75} = 14{,}400 \text{ cfs.}$$

This flow would produce a stage about 8.6 ft. above the spillway crest (3.4 ft above left abutment, 1.8 ft above the right abutment, at elevation 243.8 MSL)

APPENDIX E

INFORMATION AS CONTAINED IN

THE NATIONAL INVENTORY OF DAMS

INVENTORY OF DAMS IN THE UNITED STATES

(1) STATE	(2) IDENTITY NUMBER	(3) DIVISION	(4) STATE	(5) COUNTY	(6) CONGR DIST.	(7) STATE	(8) COUNTY	(9) CONGR DIST.	(9) NAME	(10) LATITUDE (NORTH)	(11) LONGITUDE (WEST)	(12) REPORT DATE DAY	MO	YR
NH	312	NED		11	02				MILFORD TOWN DAM	4251.0	7138.8	24	APR	79

(13) POPULAR NAME	(14) NAME OF IMPOUNDMENT

(15) REGION BASIN	(16) RIVER OR STREAM	(17) NEAREST DOWNSTREAM CITY–TOWN–VILLAGE	(18) DIST FROM DAM (MI.)	(19) POPULATION
01 05	SOUHEGAN RIVER	MILFORD	0	8100

(20) TYPE OF DAM	(21) YEAR COMPLETED	(22) PURPOSES	(23) STRUCTURAL HEIGHT (FT.)	(24) HYDRAULIC HEIGHT (FT.)	(25) IMPOUNDING CAPACITIES MAXIMUM (ACRE–FT.)	NORMAL (ACRE–FT.)	(26) LIST	(27) DAM	(28) FED H	(29) PRV/FED	(30) SCS A	(31) VER/DATE
FGLT	1900	D	12	12	130	80	FED	N	N	N		24APR79

(32) REMARKS
21=CONCRETE 23=AESTHETIC

(33) U/S HAS	(34) SPILLWAY CREST LENGTH	TYPE	WIDTH (FT.)	(35) MAXIMUM DISCHARGE (FT.)	(36) VOLUME OF DAM (CY.)	(37) POWER CAPACITY INSTALLED (MW)	PROPOSED (MW)	(38) NAVIGATION LOCKS NO.	LENGTH (FT.)	WIDTH (FT.)	LENGTH (FT.)	WIDTH (FT.)	LENGTH (FT.)	WIDTH (FT.)	LENGTH (FT.)	WIDTH (FT.)
5	195	G	173	6870		.										

(39) OWNER	(40) ENGINEERING BY	(41) CONSTRUCTION BY
TOWN OF MILFORD	NH WATER RESOURCES BD	

(42) REGULATORY AGENCY DESIGN	CONSTRUCTION	OPERATION	MAINTENANCE
NH WATER RES BD	NH WATER RES BD	NH WATER RES BD	NH WATER RES BD

(43) INSPECTION BY	(44) INSPECTION DATE DAY	MO	YR	(45) AUTHORITY FOR INSPECTION
SOUHEGAN ZOING DUNNICLIFF ASSOC	01	NOV	78	PUBLIC LAW 92-367 AUG1972

(46) REMARKS

END

FILMED

8-85

DTIC